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SURGERY, GYNECOLOGY AND OBSTETRICS

AN INTERNATIONAL MAGAZINE, PUBLISHED MONTHLY

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CANCER OF THE STOMACH[1]

BY WILLIAM J. MAYO, M.D., ROCHESTER, MINNESOTA

MORE than thirty per cent of all cancers in civilized man are in the stomach. Why should there be such an enormous percentage of cancers of the stomach? This manifestation of malignant disease is uncommon in lower animals and primitive man, yet there is comparatively no essential secretory or mechanical difference in the function or structure of the stomach. It has been suggested that the disease is connected with the formation of an acid secretion. As far as I know, no gland in the human body secretes an acid. In the colon the acidity is not a secretion of the mucous membrane, but is due to bacterial action. The kidney has no true secretion; it is a filter from which acid-forming bodies are excreted. The stomach does not secrete acid; the material for the formation of acid is brought together on the surface of the mucous membrane and the acid is formed not within but outside of the glands. Acidity of secretion and changes incident to disturbed storage function may be contributory factors but evidently they are not the responsible agents.

Does the cause concern food or drink? The difference in the nature of the food and drink of lower animals, primitive man, and civilized man is not sufficiently great to lead to the belief that food or drink of themselves could be looked upon as the important factors.

May it not be some process to which civilized man subjects food or his manner of partaking it that is the exciting agent? The only known fact regarding the causation of cancer is the influence of chronic irritation on its production. Whenever cancer exists in one species of animal or race of men in an enormous excess of what occurs in other animals or other races of men, it has been found to be owing to a single cause. Were there many causes, some would be operative among all.

The relation of chronic irritation to the more familiar forms of cancer is an interesting study. For instance, I have been able to find some evidence that cancer of the breast was an extremely rare disease in all races of people in whom the entire breast was left uncovered and exposed to the air, and that the frequency of this manifestation of malignancy was in proportion to the covering of the breast and the pressure exerted by the covering.

The theory that the frequency of cancer of the stomach in civilized man is the result of hot food and drinks which act to cause chronic irritation of the gastric mucosa is worthy of consideration. The infrequency of malignant disease of the stomach in animals and primitive man would then be explained by the fact that they take their food and drinks cold. At the general meeting of the American Medical Association in 1915[2] I called attention to the possibility that hot drinks might be the exciting agent, and

[2] Commemoration Volume, J. Am. M. Ass., 1915, p. 310.

[1] Presented before the Clinical Congress of Surgeons of North America, Chicago, October 25, 1917.

during the past two years further investigation of the circumstantial evidence related to the facts leads me to believe that it may be one if not the main cause of the tissue-changes which precede cancer of the stomach.

Why should cancer of the stomach be more frequent in the male (38 per cent) than in the female (22 per cent)? A possible answer to this question is furnished in the frequency of cancer of the posterior wall of the pharynx and upper gullet in Chinese men, who are served first while the rice is hot; the women eat at the second table when the rice is cold and rarely have cancer in this region. It is the social custom of modern civilization for the lady of the house to serve the beverages —herself last.

That heat has a remarkable influence in the production of chronic irritation has been known from the beginning of observations on cancers. Smokers' cancer of the lip, for obvious reasons, is almost confined to the male sex. The Kangri burn cancer of the Kashmir natives comprises more than half of the cancers of this race. They carry a clay charcoal burner in a wicker basket across the lower abdomen when they go into the mountains and, as a result, have heat irritation which acts to cause cancer of the lower abdomen and groins.

Here again the disease is largely among men because they are most frequently subjected to this form of tissue-insult. Locomotive engineers who are for years subjected to the prolonged heat of the fire-box have cancer of the shins arising from chronic heat irritation. Cancer of the skin of the face, which occurs so frequently among Australians that it is often called the Australian disease, begins in a peculiar climatic heat irritation.

A high percentage of persons take their drinks hotter than can be borne comfortably in the mouth. It has been shown by X-ray workers that when the stomach contains much food and drinks are taken these drinks are not carried directly into the cavity of the stomach, but, by a peculiar muscular contraction, a canal (canaliculus gastricus) is formed in the lesser curvature along which the fluids are rapidly passed into the duodenum. Eighty-five per cent of all cancers and ulcers of the stomach involve the lesser curvature, and they may have a common cause. The mouth and gullet are protected by pavement epithelium and possess sensitive nerves which give warning of injury; the stomach has no such protection.

Newer and better methods of diagnosis within the past few years have greatly extended operability and made possible radical procedures in an increasing number of patients. The early diagnosis of cancer of the stomach depends on the roentgen examination. Carman has shown that cancer of the stomach may be demonstrated in 95 per cent of cases in this way by the time they give sufficient evidence of their presence to call the patient's attention to the fact that something is wrong. Every person in whom there is suspicion of cancer of the stomach should be promptly subjected to examination by the roentgen ray. All persons with an anæmia which cannot be otherwise explained should be subjected to such examination. Cancer of the body of the stomach and cancer of the cæcum and ascending colon may produce striking anæmias early, before there are local symptoms.

Mechanical conditions arising from the frequency with which the disease originates in the pyloric end of the stomach is a fortunate occurrence and leads to early diagnosis. The presence of a movable tumor in this situation, even of considerable size, is a favorable indication and not, as it is so frequently looked upon, a sign of inoperability. If the cancer as it appears in the stomach is mechanically removable, even if all the glands and indurated tissue cannot be removed, I believe resection is still advisable. The mortality will be very little higher than after gastro-enterostomy, palliation will be many times greater, and occasionally a patient will be cured. I have never forgotten a lesson learned from a search of our statistics on gastro-enterostomy for the palliation of clinically inoperable cancer of the stomach, in which a section had not been removed for microscopic examination. Five of the patients thus operated on lived more than five years, showing that a clinical diagnosis of inoperable cancer is open to error.

Chronic ulcer of the stomach is not often cured medically and I am convinced it is a potential source of gastric cancer. We cannot question the fact that in the past many patients have been treated for the diagnosis of ulcer, not for the disease. When ulcer is shown in the roentgenograms, other things being equal, it should be removed by actual excision and gastro-enterostomy, which gives a mortality of about 5 per cent; or better, after the removal of tissue for microscopic examination by frozen section, the ulcer should be burned out with the cautery after the method of Balfour,[1] and followed by gastro-enterostomy. There were but two deaths in 198 operations by the latter method (a mortality of about 1 per cent).

In cases of cancer of the pylorus, resection by the second method of Billroth leaves little to be desired. For cancerous ulcers high up on the body of the stomach, occasionally a resection in continuity (segmental resection) may be indicated, but for cancer of the pyloric end of the stomach and lesser curvature, which constitute the great majority of cases, wide removal followed by closure of the end of the duodenum and direct anastomosis between the cut end of the stomach and the side of the jejunum—antecolic—is the operation of choice. This method extends operability, and enables the speedy removal of growths which would not be operable by any other method with which I am acquainted. On a number of occasions the operation has been completed in less than forty minutes.

The posterior end-to-side operation as first described and practiced did not produce better operative mortality statistics than the Billroth II, but it did increase operability. The cause of the mortality in the posterior method (end of the stomach with the side of the jejunum) concerned the transverse colon and transverse mesocolon. It was difficult, consumed time, and occasionally it was impossible to fasten the anastomosed area below the opening in the transverse mesocolon. If this was not done the mechanical conditions often proved unsatisfactory. By the antecolic method a length of jejunum, sufficient for a free loop (16 to 18 inches), is passed around the omentum and transverse colon, and easily brought to the gastric stump for anastomosis. By this method, it was found possible to reach a point for section still higher on the stomach than by any previous method and the mortality dropped from 13.2 per cent average to 6 per cent in an equally advanced or even more advanced group of cases.

Some of the operations in our series were very extensive. In nine cases the resections were subtotal, that is, the whole of the stomach was removed, except just enough to enable an anastomosis to be made. In one instance I removed the entire stomach by the Moynihan method and with it a margin of the œsophagus. The patient made an excellent recovery and has surprisingly good function.

What results may be expected from radical operations for cancer of the stomach? We have eliminated all resections of the stomach made previous to 1897, as up to that time a specimen was not regularly subjected to microscopic examination. Taking the twenty years from October 10, 1897, to October 10, 1917, there were 651 resections of the stomach for cancer. Of 427 patients operated on more than three years ago who recovered from the operation, 311 have been traced; 120 (38.6 per cent) were alive three years or more after operation. Of 313 patients who were operated on more than five years ago, 239 who recovered from the operation were traced, and 62 (26 per cent) of these were alive five years or more after operation. In compiling these statistics we have assumed that the deaths which occurred were from recurrence of cancer. This assumption is unwarranted, as the Medico-Actuarial Mortality Investigation Tables show a normal death rate at the average age of these patients (52 years) of 4.2 per cent for a three-year period and 7.5 per cent for a five-year period. These percentages, so far as the cure of cancer is concerned, could be fairly subtracted from the death rate and would add by so much to the percentage of cures. It has been our experience that the patients we have not been able to trace following operation and whose ultimate

[1] Balfour, D. C. Restoration of gastro-intestinal continuity by means of antecolic gastrojejunostomy following partial gastrectomy for cancer of the pyloric end of the stomach. Surg., Gynec. & Obst., 1917, xxv, 473-477.

condition has been ascertained in after years have shown a higher than average percentage of cures. No special effort was made to trace patients after the five-year period, but incidentally it was learned that 35 lived 6 years or more after operation, 27 lived 7 years or more, 18 lived 8 years or more, ten lived 9 years or more, 7 lived 10 years or more, 5 lived 11 years or more, 3 lived 12 years or more, and one lived more than 15 years after operation. These statistics of actual cures compare favorably with those of cancer in other parts of the body and show that the radical treatment of cancer of the stomach is keeping pace with the modern treatment of cancer in general.

CANCER OF THE STOMACH[1]

By ALBERT J. OCHSNER, M.D., Chicago

THE paper which you have just heard contains two of the characteristics with which you are familiar from your knowledge of Dr. Mayo's writings. The first of these characteristics has been of enormous benefit to the surgical profession, not only of this country, but of the entire world. The paper contains something that every one of you who is a surgeon can take home and make use of, something that he can apply for the benefit of his own patients. It has practical value.

It also contains something that will cause you to think and to review the work that you have done, and think over the patients you have seen and the observations that you have made. It gives you something to meditate over. It has value from the standpoint of inspiration.

You are impressed with the fact that a condition to which every one is exposed is an important matter to consider in studying the causes of this most fatal of all diseases.

We have known for a long time that there is no superficial cancer, whether it be within the cavities of the body or upon the surface, which occurs without preliminary irritation. We know that this preliminary irritation gives rise to disturbed circulation. We suppose that this condition of disturbed circulation gives rise to a pathological condition, either directly, as most of the authorities hold, who are supposed to know something about this disease, or by producing a condition which makes it possible for the true living irritant that causes the formation of cancer to become successfully active.

I am sure that there are enough farmers among you to understand what I mean when I say that when you see clover growing you know that the soil is not acid. You can tell when you see certain weeds growing that the soil is not alkaline.

To my mind, no matter how thoroughly the soil for the production of cancer may be ready, unless there is a disturbance of the circulation, unless there is a condition present which inhibits the natural protection of the tissues against the development of the living cause of cancer, cancer cannot be produced.

We have an illustration in smoker's cancer, one of the examples which were given here. Why does smoker's cancer practically never occur in the upper lip? Is not the upper side of the pipe stem as warm as the lower side? Is it not true that although the patient may not keep his upper lip in contact as long as the lower lip, he keeps his upper lip in contact with the pipe stem much longer than many others, who secure a cancer, do the lower lip? The fact is that the upper lip does not have its circulation disturbed, because you have simply the heat there and you have not the disturbance of the circulation due to continued pressure.

Why is it that in the alimentary canal you have cancer on the proximal side of the sphincter of the pylorus; and why do you nót have cancer on the proximal side of the sphincter of the ileocæcal valve? Why do

[1] Discussion of paper by William J. Mayo, presented before the Clinical Congress of Surgeons of North America, Chicago, October 25, 1917.

you have no cancer on the distal side of the sphincter of the pylorus; and why, as a matter of fact, do you have cancer on the distal side of the sphincter of the ileocæcal valve?

There is another element which Dr. Mayo mentioned, namely this, that on the proximal side of the sphincter of the pylorus and on the distal side of the sphincter of the ileocæcal valve you have an acid condition. As stated before, clover cannot grow in acid soil any more than certain weeds can grow in alkaline. We have on the proximal side of the ileocæcal valve and on the distal side of the pylorus an alkaline solution; on the other side of each of these valves we have an acid solution.

Why do we frequently have a cancer at the upper end of the rectum, while we have a cancer at the hepatic flexure of the colon only occasionally, and more often at the splenic flexure? May it not be because from the anatomical arrangement of the large intestine there is stasis and consequent irritation of the walls of this organ at these points due to the accumulation of fæcal material, and this condition is most marked in the upper end of the rectum, less at the splenic flexure, and still less at the hepatic flexure, which interferes with the circulation.

Those of you who are familiar with the literature concerning cancer in fish will remember that the fish that lived in clean water did not develop cancer. Those that lived in water that was slightly soiled by the excreta of these fish had cancer, in small proportion. Those that lived in water that was badly soiled had cancer in large proportion. Where did these fishes have cancer? The cancer was located in the gills. Why do these fish have cancer in the gills? Does it not seem reasonable to suppose that this is because their gills are exposed to an enormous extent to this soiled water? Did they have cancer in the alimentary canal? No, because the alimentary canal did not come in contact with this soiled water.

Why do we have 30 per cent of our cancers in the stomach? May it not be because the stomach comes in contact, in large proportion, with food that is not clean?

Why do civilized people have cancer of the stomach more frequently than do Indians? Is this not because civilized people are manure eaters? Why do they have an enormous amount of cancer of the stomach in Japan, and practically no cancer of the stomach in people who live within a few hundred miles away from Japan, who do not fertilize their gardens with night soilage? Is this not because you must have a specific infectious substance aside from the local irritation to cause cancer?

You may say that because you have not as yet found the organism that needs this preparation for its growth, that therefore we have no right to say that it exists. Who doubts the fact that smallpox is due to a living thing, or that scarlet fever or measles or whooping cough are due to living things, and so on indefinitely?

We have not as yet found the living thing that causes cancer, but we have found the conditions that make it possible for this living thing to get a foothold in the human tissues and to live successfully under these conditions.

It seems to me that logically we must continue to search for the living cause of cancer, especially in view of the fact that a specific organism has been demonstrated which causes cancer in plants. Because we know that irritation has to precede the development of cancer, we must not lose sight of the fact that we have not searched far enough for a living cause. We must avoid irritation. We must teach our patients that they must not eat unclean food unless it has been cooked. We must teach our patients that they must not irritate their tissues, and that exposure to heat produces a dangerous form of irritation. We must have them understand it; we must make the public in general understand this.

But we should at the same time insist upon having clean food to put into the alimentary canal. I am convinced that when this is done, we will have an enormous decrease in the amount of cancer.

THE RESTORATION AND REPAIR OF THE WOUND, COMBATING CONTAMINATION AND INFECTION[1]

By Major GEORGE W. CRILE, M.R.C., U.S.A.

THE restoration and repair of the wound may be divided into four stages, each presenting its own problems: (a) The stage of depressed local resistance and contamination, i.e., the first twelve hours; (b) the stage of infection; (c) the stage of granulation and healing; (d) the superficial healing of wounds; end-defects, sinuses, deformities, etc.

Obviously, each of these stages presents a specific set of problems each so different from the rest, that no one set of procedures will answer for all.

In the stage of depressed local resistance and contamination, the indications are (a) restoration of depressed local resistance; (b) destruction of the contaminating bacteria.

The restoration of depressed local resistance includes (1) excision revision; (2) physiologic rest.

1. *Excision revision.* The depressed resistance of a contused wound may be most quickly raised by immediate excision of its partially devitalized tissue. This must be done lightly and sharply; for if there be rough handling, needless moving of compound fractures, if piercing hooked retractors tear the flesh, and if intermittent muscular contractions grind tissues between the ends of ragged bone fragments, then the net result of excision revision is the substitution of surgically devitalized tissue for the devitalized tissues of battle casualty. With the aid of damaging inhalation anæsthesia, the rough surgeon does slowly and awkwardly what shrapnel does painlessly and quickly—the shrapnel injury is to be preferred!

Next in importance to excision revision is the application of the great physiologic principle so clearly set forth in an earlier day by Hilton, appreciated by the civil surgeon everywhere, reaffirmed in war surgery by Sir Anthony Bowlby, General Makins, indeed by British surgeons generally, and no less by Sir Almroth Wright, viz., physiologic rest. In the last analysis, the resources of the patient are the only means of restoration and repair.

2. *Physiologic rest.* Physiologic rest includes more than mere muscular and psychic rest; it implies equally cellular rest. Living cells are disturbed by air; by desiccation; by physical contact of dressings; by many chemical antiseptics; by bacterial toxins. These points have been strongly emphasized by Sir Almroth Wright whose teaching has given the impetus which has led to the *cellular* protection of wounds, to insure cellular physiologic rest.

To secure physiologic rest in the case of a fracture, an even adequate continuous extension must be made—an extension sufficient to prevent the goading of soft tissues by sharp bone, and to prevent bony fragments from grinding each other. Physiologic rest of the soft parts means mass quiet by means of supports—such as splints, slings, swings, and extension suspensions; it means for compound fractures and for injuries of the soft parts no tight bandages, no tight stitches, no accumulation of wound secretions—blood, serum, etc. For open wounds it means that antiseptics must not be damaging; that dressings must be painless; it means elevation for comfort and the prevention of swelling. For visceral injuries it means absolute rest, low diet, freedom from excitation, anociated environment. Physiologic rest implies no transport, no painful dressings, no alarms. It means noiseless steps and quiet neighbors.

In the destruction of contaminating bacteria, the first and most dependable agency is the bactericidal power of tissues. This normal defense of tissue against bacteria is present only in living tissues; and the ability of living tissue to overcome infection depends on its vitality. Normal living tissue has strong bactericidal power. As vitality is impaired down to the death point, so is the bactericidal power impaired to the zero

[1] Presented before the Clinical Congress of Surgeons of North America, October 22–25, 1917.

point. Moreover, when infection begins, the infecting agent itself has the power of diminishing the vitality in advance of the infection through chemical injury, tension and swelling. Thus as Kenneth Taylor, Cuthbert Wallace, Bashford and others have shown, many anaerobes cannot live at all in normal tissue, but only in damaged tissue. The anaerobic invasion is made possible only by injury through chemical action, through shell injury, through swelling or anæmia whereby the resistance of the tissue is lowered. Pyogenic infections attack most successfully in the wake of a creeping damaging barrage. Therefore, in a compound fracture that is settling down, one goading by a ragged bone will devitalize a small area and in consequence an area of infection with its advancing barrage will be established. Therefore, we may say that the whole wound is defensively only as strong as its weakest point. If the defense line is broken at one point, the entire line may give way.

As for antiseptics, no chemical antiseptic can command good results with bad surgery; good surgery commands good results without chemical antiseptics, but the best results are the sum of good surgery and the good use of good chemical antiseptics. In the period of contamination, the state of depressed vitality of the wound is overcome by exquisite excision of devitalized tissue; by general and local physiologic rest; by assisting the reinvigorated wound to overcome the contamination by the use of antiseptics that do not interfere with the defense of the wound; by leaving the wound temporarily open. If this plan be carried out, the incidence of acute infections will be minimized, and the wound may be closed early by loose stitches or by adhesive plaster.

This is why excellent surgeons may quite disregard antiseptics—for the same reason that Lawson-Tait required no antiseptics—it is because the work of Sinclair and Tait produces rifle wounds, while the rest of us produce shell-torn wounds. If it is a military necessity that a patient be rushed down the lines of communication and if the attention of the surgeon is focused away from the principles of surgery and only toward the antiseptic—to the degree that good surgery is out of the reach of both the patient and the surgeon, to that extent must antiseptics be depended upon. When the wounded are being received in wholesale numbers; when isolated from surgical ways and means; when evacuation is urgent and continuous travel compelled; when inexperienced surgeons and internists must take the place of good surgeons; when the shelter of a cave must needs become a hospital—then antiseptics are a boon. Again, if a wound has become infected in the midst of good surgical opportunity, antiseptics may be required. If antiseptics are required, then the choice at present would lie among Carrel-Dakin, "b. i. p.,"[1] eusol, the recently proposed dichloramin-T, and flavine.

If the opportunity exists, i.e., if there is sufficient assistance, if the wounds are deep and extensive, Carrel-Dakin is probably the choice. If through the rush of large numbers of cases or through want of help, Carrel-Dakin cannot be *well* administered then "b. i. p." is indicated. "B. i. p." is an excellent dressing for travel as the wound requires no care for several days. If the wound be deep or superficial, if there is a rush, a good "b. i. p." dressing is better than a *defective* Carrel-Dakin. Many wounds do well with eusol, and many cases travel well with a Wright pack. The ideal antiseptic would be a form of energy such as the ultra-violet ray, Coolidge tube, or electrolysis, whereby the entire wound and the surrounding tissue could be sterilized at a single seance of short duration. Solar energy and electric light energy are excellent antiseptics, but are not available for war surgery in the area of the advance. Conditions are variable—methods must be variable. Relative values may be summed up as follows: About 80 per cent of a good result is due to a good surgeon and good surgical opportunity; 10 per cent to chemical antiseptics, and the remaining 10 per cent to after-care.

In the stage of infection, the treatment consists chiefly in physiologic rest in the broadest sense; and in addition, if there is sufficient pain, redness and swelling to indicate the

[1] B. i. p.: Bismuth, 25 parts; iodoform, 50 parts; paraffin, 25 parts.

actual presence of an invading infection, many and free incisions should be made into the area of infection—throughout the area of infection—until redness and the damaging tension disappear. The reason for the good effect of free incisions is that they remove an interference with the normal vital defense. In addition to free incisions, heat, preferably moist heat, physiologic rest of the man as well as of the wound, and elevation of the wounded member are indicated. Not only free but dependent drainage is always indicated. If, however, the Carrel-Dakin method is used then pool and do not drain. If the numbers of wounded make the Carrel-Dakin treatment impossible, and this is the rule during active warfare, then use "b. i. p." Good surgery contributes about 80 per cent of the treatment. Of the remaining 20 per cent, about 10 per cent may be contributed by antiseptics; about 10 per cent by after-care.

During the period of acute infection, the following should be avoided—pain, lipoid solvent anæsthetics, rough handling. Rough handling of infected compound fractures under ether or chloroform anæsthesia, not only spreads local infection, but promotes septicæmia. If one were endeavoring to produce septicæmia experimentally, one of the best methods would be to first "gas" the phagocyte with chloroform or ether; and then "bonejab" through the established line of defense.

The acute infection period is usually past in four days, leaving a granulating surface protected by a strong line of defense—the wound is now well "dug in." The wound that has cleared contamination before infection and the wound that has gone through the stage of acute infection next enter the stage of granulation and healing.

In the granulation and healing stage we have to deal with: (a) contaminated wounds that have become relatively sterile and may be closed; (b) infected wounds that have become relatively sterile and may be closed; (c) wounds with too much loss of tissue; (d) wounds too deep and too extensive for closure.

The closed wounds require no further discussion. The deep wounds, such as compound fractures, present one fundamental problem, viz., the prevention of the pocketing of pus.

The pocketing of pus should be met by real dependent drainage; by correct suspension extension. The accumulation of pus is prevented by what Sir G. H. Makins has aptly termed "curtain drainage." Curtain drainage with simultaneous antiseptics under war conditions is at present best achieved by "b.i.p." or the Carrel-Dakin method. Dichloramin-T holds out much promise.

The ideal method by which to secure *superficial healing* is by immediately covering the surface by skin graft; otherwise, hot packs of eusol or normal saline, alternating with electric lights or sunlight give the best results. When superficial healing has been accomplished, the patient has been brought to the final stage—the stage of sinuses, of osteomyelitis, of deformities, of defects, of aneurisms, of nerve injuries, of scar contractures, none of which will be considered here.

SUMMARY

Choice of antiseptic methods in the period of contamination. With adequate wound revision; physiologic rest for the wound and for the man; and good hospital care, what is the method of choice in: (1) fresh, superficial open wounds; (2) fresh deep wounds—such as compound fractures of the thigh; (3) in the midst of a deluge of patients during heavy engagements; (4) when there is a shortage of surgeons.

An open, fairly superficial wound without inaccessible areas does admirably with normal saline, Carrel-Dakin, "b. i. p.," eusol or electric light,—perhaps best of all by the last named. A wound with deep injured areas will do well treated by the Carrel-Dakin method or "b.i.p." In a great rush, "b.i.p." is indicated.

Choice of methods in the period of acute infection. With free incisions; the best posture and physiologic rest what further treatment is indicated for (1) accessible areas; (2) inaccessible areas; (3) in stress of work; (4) when nursing and professional staff are inadequate.

If conditions permit, the best single treat-

ment undoubtedly is hot packs; in time of stress, "b. i. p."; in deep wounds, dependent drainage; in quiet times, Carrel-Dakin. When the wounded come in waves, and surgeons and nurses are swamped, incision and "b. i. p." give the best results to the greatest number per surgeon. But "b. i. p." must be spread on thinly, not applied in masses and the *wound should not be sutured* but should be lightly packed.

Choice of antiseptic methods in the stage of healing. In accessible wounds, the best treatment consists of sunlight or electric light, with eusol or Wright's hypertonic solution, and hot packs applied for an hour night and morning. In the absence of sunlight or electric light, however, use a protective dressing. In deep inaccessible areas—granting always dependent drainage and physiologic rest, use "b. i. p.," or instead of drainage pooling with Carrel-Dakin. It must be remembered that owing to the lack of dependent drainage, if Carrel-Dakin goes wrong it goes badly wrong.

Meaning of physiologic rest. Physiologic rest implies no irritating dressings, comfortable position, no compressing bandages, no painful handling, even and balanced muscular pull, no accumulation of wound discharges, apparatus that will permit necessary moving about in bed without breaking physiologic rest.

PRESENTATION OF A RADICAL OPERATION FOR TUBERCULOSIS OF THE SEMINAL TRACT

By HUGH HAMPTON YOUNG, M.D., F.A.C.S., Baltimore
From the James Buchanan Brady Urological Institute, Johns Hopkins Hospital

In 1900 the writer (1) presented a new "suprapubic retrocystic, extraperitoneal method of removing the seminal vesicles" and during the next year (2) published an exhaustive study of the literature and added additional cases of his own. At that time there had been only five cases in which a radical removal of both seminal vesicles had been carried out, and the author was able to add two cases by the new method mentioned, in which both seminal vesicles with vasa deferentia, the upper portion of the prostate and both testicles were removed *in toto*. These two cases were the only ones in which the entire seminal tract on both sides, with a portion of the prostate, had been removed. (Figs. 23 and 24.)

Material for this survey was principally afforded by various case reports in the foreign medical journals, there being but three cases in which tuberculous seminal vesicles had been removed in this country (cases of Weir 3, Bolton, 4, and Finney). The operative methods which had been employed were varied, and all were remarkably unsatisfactory. The primary mortality was very high (25 per cent), and the number of cures extremely small, so that the writer was forced to draw the conclusion that radical operations upon tuberculous seminal vesicles were not to be considered. This conservative standpoint was further strengthened by reports from Kocher's clinic which showed that after excision of tuberculous testicles the remaining process in the seminal vesicles and prostate, in most instances, completely disappeared or became so much improved as to give very little trouble; and articles by Bardenheuer (5) and by Demitresco (6) showed remarkable results with simple epididymectomy. On this account the writer advised in cases of tuberculosis of the seminal tract (viz., testicles or epididymes, vasa deferentia and seminal vesicles or prostate) that the proper procedure was epididymectomy (or castration if the testicle was involved), with drainage of the vas deferens through the upper angle of the incision in the groin, and injection of seminal vesicles with iodoformized oil through vas at frequent intervals after operation.

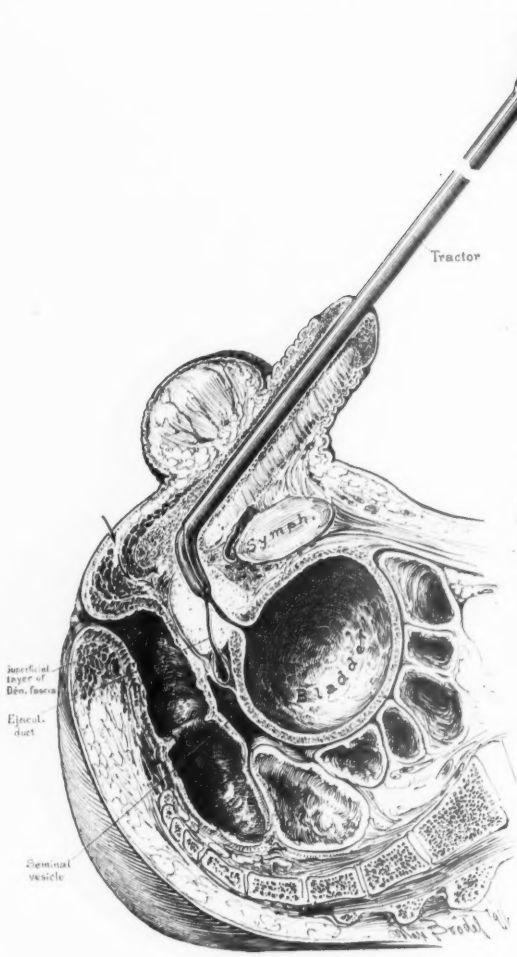


Fig. 1. Showing the anatomy, arrows indicating route. Tractor in urethra.

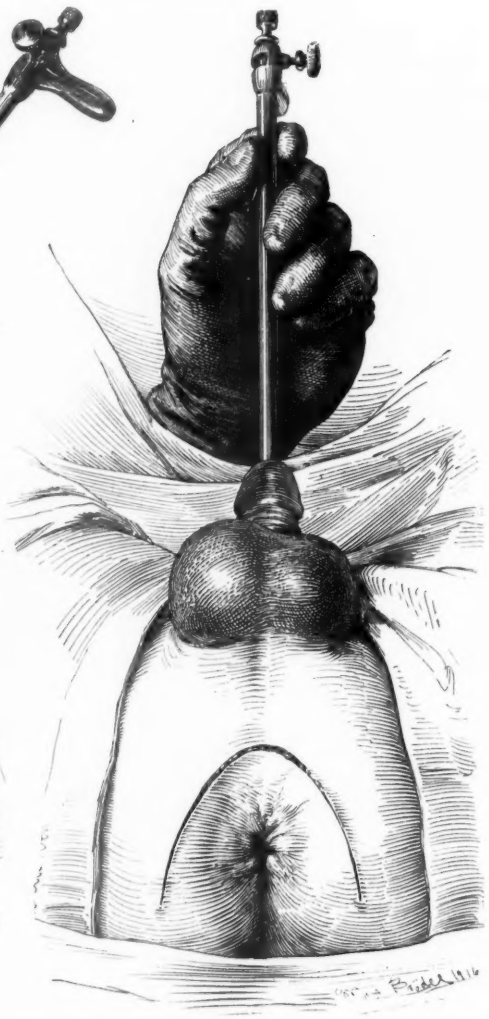


Fig. 2. Showing the cutaneous incision. Tractor in urethra.

For ten years this procedure was followed, at our clinic, with, at times, very satisfactory results. In some cases the tuberculous process in the prostate and vesicles did undoubtedly retrogress so as to become almost negligible, but in some cases the outcome was not so favorable, and as years rolled by and these patients were carefully followed, more and more instances arose in which the patient became progressively worse, the urethra and bladder became involved, and death ensued from a generalized tuberculosis. Even when this did not occur, in some instances, life was rendered miserable by pain, dysuria, hæmaturia, and other disabling complications.

Our attention was again directed to the question of radical operation, and a review

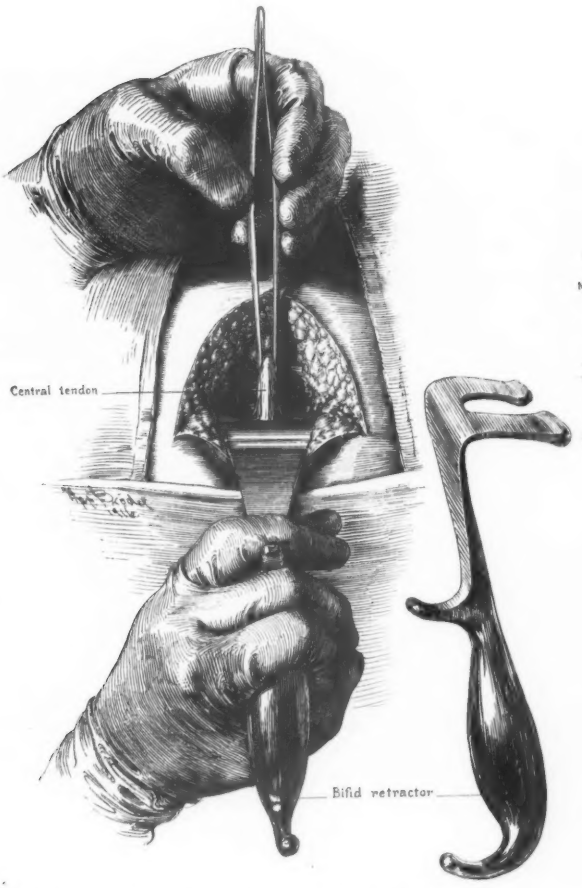
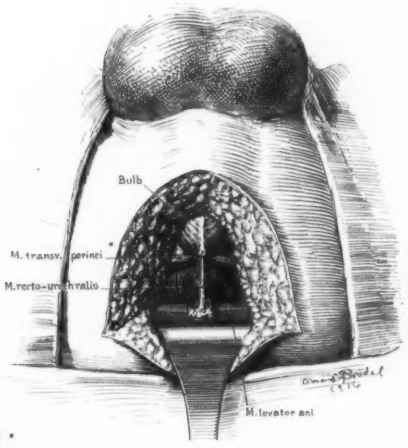


Fig. 3. Central tendon put on tension by bifid retractor, previous to division.



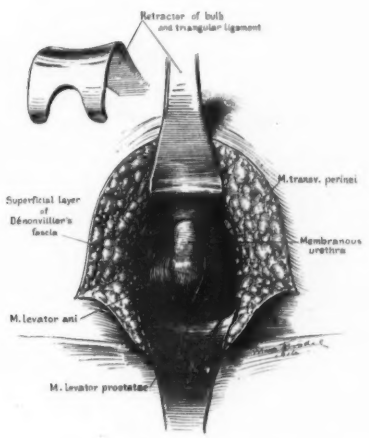


Fig. 4 (above). Central tendon has been divided, exposing recto-urethralis muscle which is next divided.

Fig. 5. Special retractor of bulb and triangular ligament has been inserted, exposing membranous urethra, held up on tractor. Levator ani muscles next pushed to each side exposing posterior or superficial layer of Denonvilliers' fascia.

of the various methods which had been employed, was made. The vesicles had been approached through the perineum, through the rectum (paralleling the sacrum and rectum) and through the groin. The writer had, himself, in 1900 proposed a suprapubic retrovesical extraperitoneal operation in which, after stripping the peritoneum from the posterior surface of the bladder, the seminal vesicles were completely removed, along with the vasa deferentia, epididymes or testicles. But in these cases the operative procedure was unsatisfactory on account of poor drainage, usually resulting in miliary tuberculosis. Those cases which had been operated on through the groin and iliac regions suffered from the same complications. The parasacral and pararectal routes were difficult, mutilating, applicable only to one seminal vesicle, and associated with a high mortality. The perineal route alone was left, and on examination showed that poor results

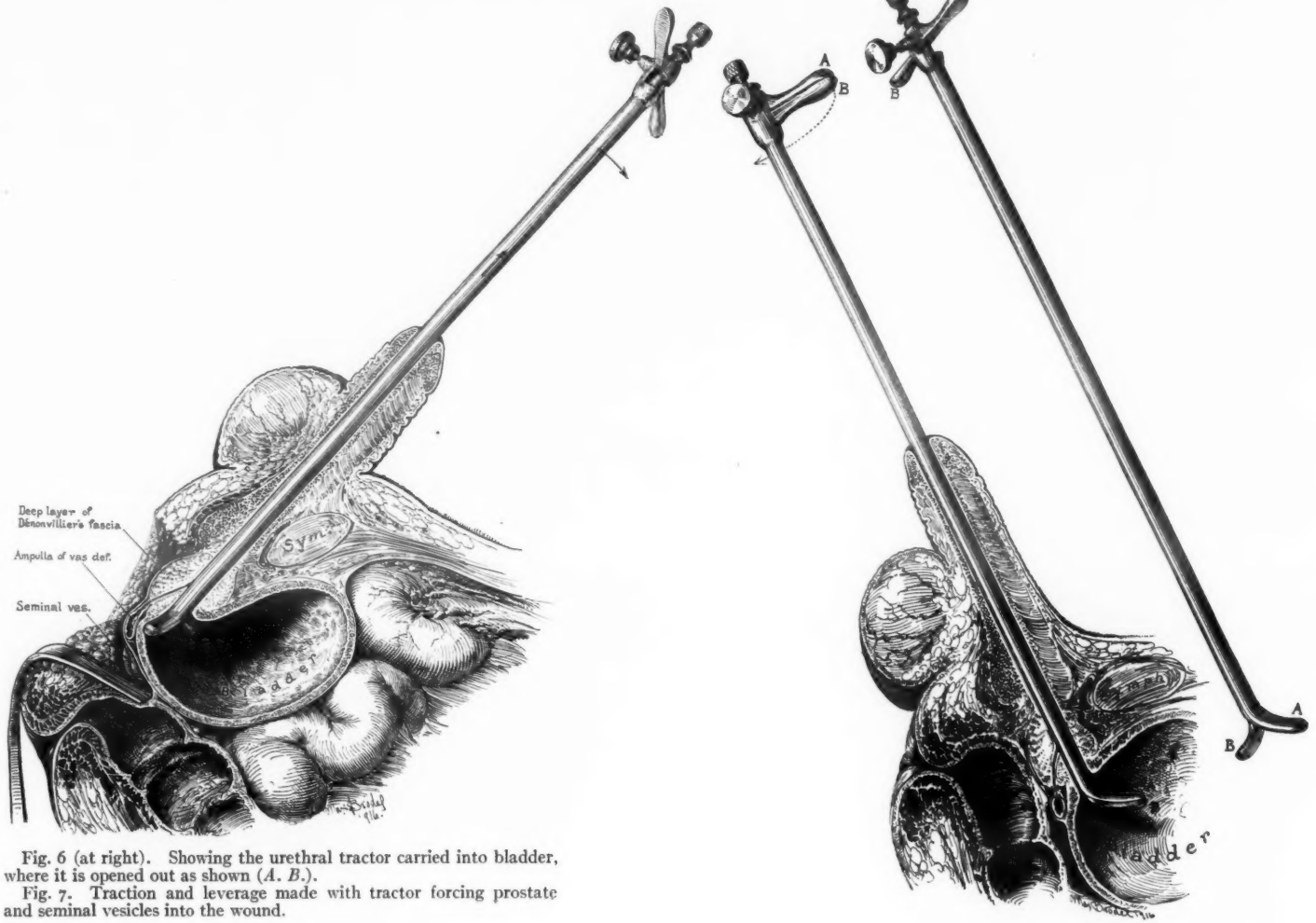


Fig. 6 (at right). Showing the urethral tractor carried into bladder, where it is opened out as shown (*A. B.*).

Fig. 7. Traction and leverage made with tractor forcing prostate and seminal vesicles into the wound.

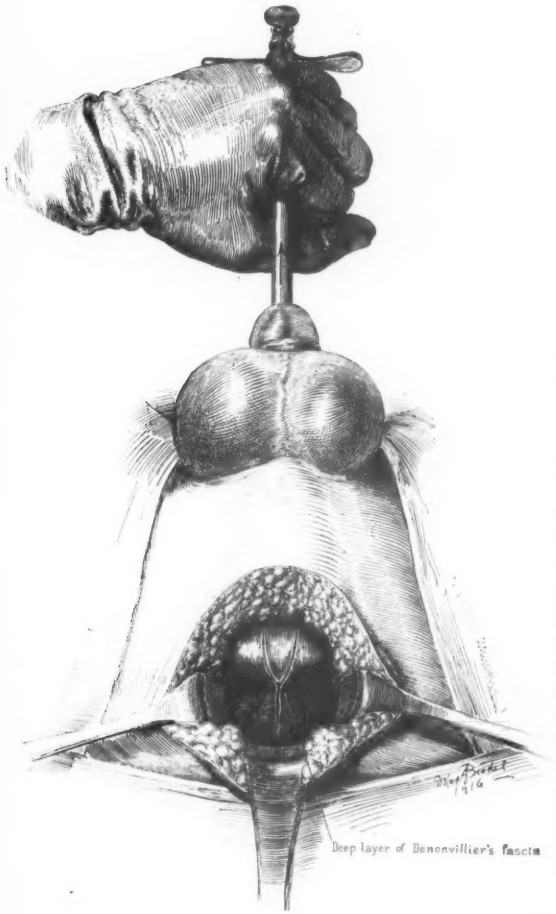


Fig. 8. Levators and rectum drawn away, exposing fascia of Denonvilliers. Y-shaped incision through fascia.

had been obtained largely through imperfect technique and the inability to reach and thoroughly expose the tuberculous vesicles and vasa deferentia.

In the meantime (1903) the writer had devised and promulgated his conservative perineal prostatectomy by means of a two-bladed prostatic tractor which facilitated the exposure of the prostate and made it possible to draw down even huge intravesical prostatic lobes and to enucleate them easily through the perineum. Cases of prostatic hypertrophy were encountered in which the

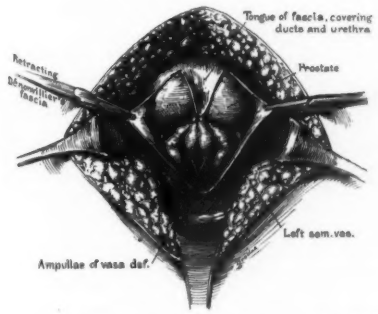


Fig. 9. Fascia of Denonvilliers elevated by blunt dissector exposing lateral lobes of prostate, seminal vesicles and vasa deferentia.

seminal vesicles were diseased and it was found easily possible to draw down, thoroughly expose, and operate upon the seminal vesicles, in addition to removing the prostate. It, therefore, occurred to the writer in 1913 to use similar methods for tuberculous seminal vesicles. One of the principal objections to previous operations through the perineum was the usual development of chronic urinary perineal fistulæ. In order to avoid this, a tractor of more delicate caliber and longer shaft was constructed which could easily pass (Fig. 1) through the penile urethra into the bladder and thus be used for traction without opening the urethra through the perineum, as shown in the illustrations of Mr. Broedel demonstrating the development of this operative procedure.

The ordinary inverted V perineal incision (Fig. 2) which I have always employed for perineal prostatectomy, has been found entirely satisfactory, and after division of the central tendon and recto-urethralis muscle (Figs. 3 and 4), the membranous urethra and apex of the prostate are easily exposed without cutting the levator ani muscles (Fig. 5). Up to this point the tractor has been introduced only sufficiently far so that its beak lies in the membranous urethra, thus giving an index as to its location. It is then carried into the bladder, opened out, traction made and pressure employed (Figs. 6 and 7), thus by leverage forcing the prostate and seminal vesicles up into the wound where little difficulty is experienced in uncovering

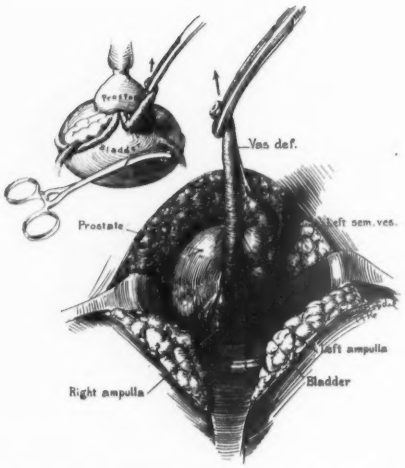


Fig. 10. Left seminal vesicle freed, vas divided between clamps.

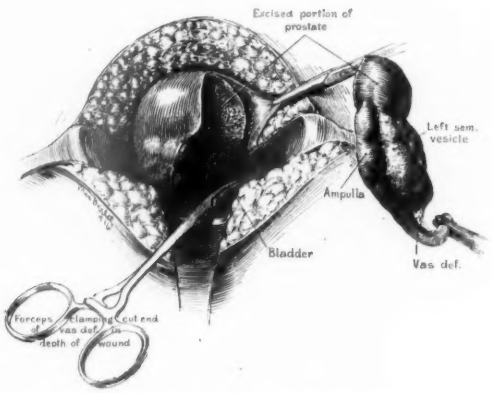
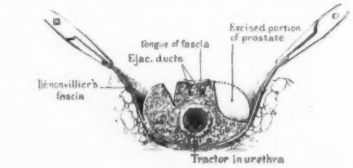


Fig. 11. Vas, vesicle, and most of left lateral lobe of prostate have been removed in one piece. Note division of ejaculatory duct near urethra.

the fascia of Denonvilliers, the anterior layer of which forms the covering of and index to the seminal vesicles and vasa deferentia as well as the prostate. In this exposure the levator ani muscle is drawn outward and backward with the rectum exposing the superficial or posterior layer of Denonvilliers fascia, which is divided near the apex of the prostate, thus uncovering the shining anterior or deep layer of Denonvilliers' fascia. The incision which must now be made through the fascia of Denonvilliers in order to expose the vasa and seminal vesicles may vary somewhat according to the extent and character of the involvement, but as a rule a Y-shaped incision (Fig. 8) has been found most satisfactory for nearly all cases in which both seminal vesicles, ampullæ and lateral lobes of the prostate are involved. The fascia is then elevated on both sides, thus exposing



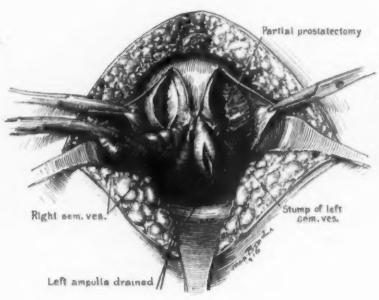


Fig. 12.

Fig. 12. Variation: left vesicle and lobe of prostate excised, and vas drained. Right vesicle being freed. Note line of incisions in prostate (above).

Fig. 13.

Fig. 13. Variation: showing drainage of vas and vesicle for chronic inflammation. Posterior wall of vesicle excised.

Fig. 14.

Fig. 14. Showing drainage and suture.

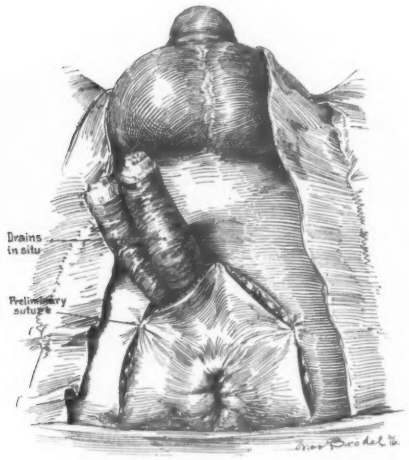


Fig. 15. Showing closure and drainage of perineal wound.

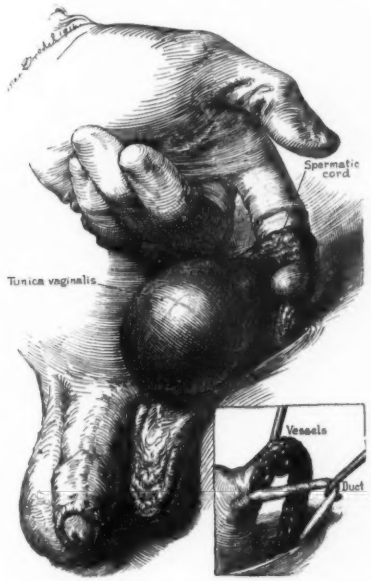


Fig. 17. Cord and testicle delivered. Separation of vas from vessels.

the lateral lobes of the prostate, ampulla, and seminal vesicles, and leaving the central portion of the prostate immediately beneath the urethra (in which the ejaculatory ducts lie) intact and covered by fascia which aids in protecting them. An excellent exposure is thus obtained (Fig. 9) and it is possible to determine exactly how much should be removed, whether the disease is unilateral or bilateral, and whether one or both lobes of the prostate shall be excised. Another advantage of this method is that the main blood supply which lies externally is thus drawn outward with the fascia and hæmorrhage is avoided, making it possible to see well and to carry out a delicate and accurate blunt dissection without injury of the bladder, to which the ampullæ and vesicles are often very adherent. The vas deferens should be freed well up toward the point where it winds around the ureter and then deeply clamped and divided, the upper clamp being left attached to assist in removal of the upper portion of the vas deferens, in case epididy-

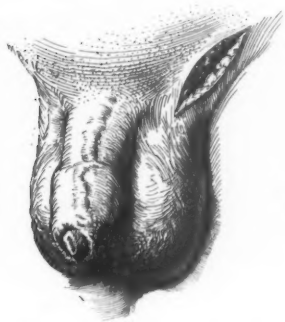


Fig. 16. Incision in groin. Patient in horizontal position on back.

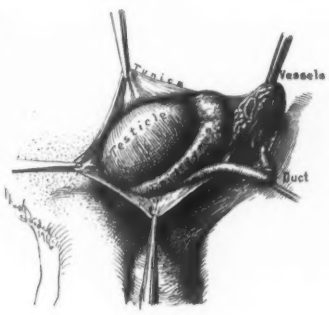


Fig. 18. Tunica vaginalis opened, exposing tuberculous epididymis.

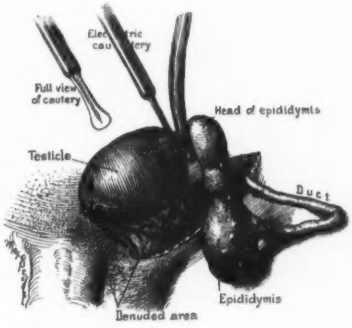


Fig. 19. Excision of epididymis completed with electrocautery.

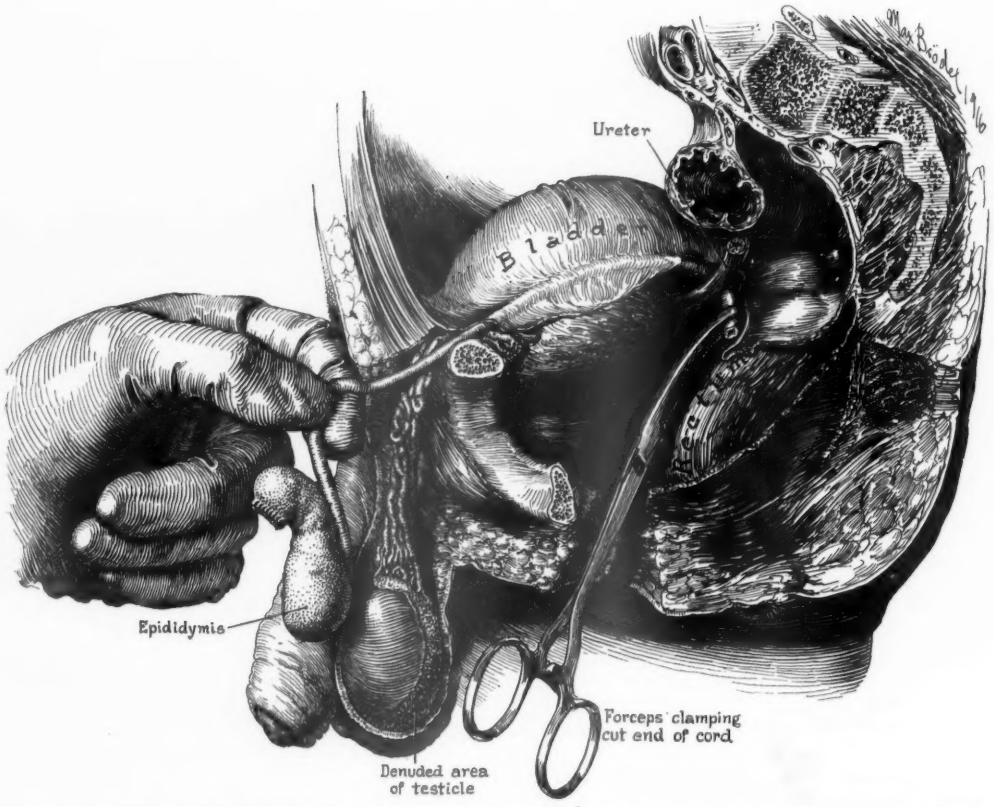


Fig. 20. Showing method of traction (alternating between operator in groin and assistant pulling on clamp in perineal wound on vas) by which vas is freed and then drawn out through inguinal canal.

mectomy or castration is contemplated. The seminal vesicle on this side is then freed, firm adhesions being clamped and ligated after division in order to prevent bleeding, and, working from above downward, the seminal vesicle and ampulla are freed until the juncture with the upper portion of the prostate is reached (Fig. 10). If it seems desirable to remove a portion of the prostate, an incision is made parallel to and at a distance of 5 millimeters from the urethra (and dividing the ejaculatory duct) but leaving sufficient tissue to avoid a urinary fistula (Fig. 11). After this, the prostatic tissue is easily removed by enucleation from within its capsule, and the fascia, ampullæ, seminal vesicles, and lateral lobe of the prostate are thus removed in one piece as shown in the illustration (Fig. 22.) If the disease is bilateral the same procedure is carried out on the opposite side (Fig. 21) and the wound then partly closed, the long clamps being left attached to the upper ends of the vasa deferentia for traction later. In this closure two iodoformized gauze drains are provided, the levator ani muscles are brought together (Fig. 14), and the wound closed as in prostatectomy, leaving room for drainage (Fig. 15). The patient is then placed on his back and epididymectomy or castration carried out according to the extent of the lesion present. This is also so well shown in illustrations that detailed description seems unnecessary. The incision is usually made

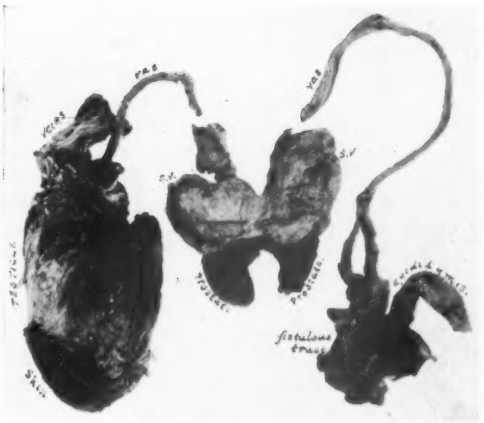


Fig. 21. Case 4322. Photograph of specimen showing removal of both vesicles, vasa and lateral lobes of prostate; median portion and urethra preserved. Castration on one side, epididymectomy on other.

along the cord just below the external ring (Fig. 16) and, after division of the dartos, the

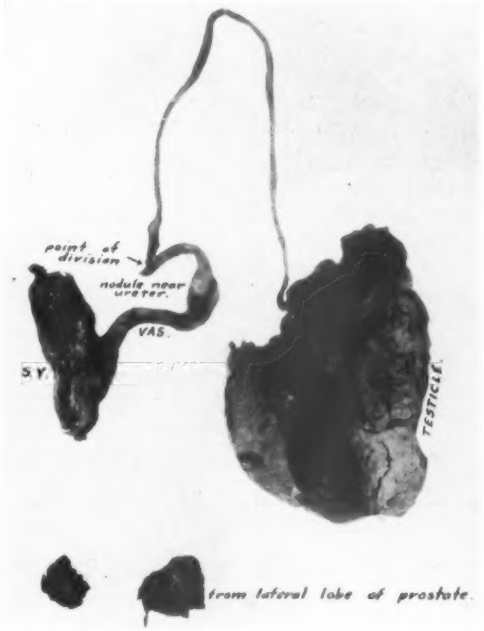


Fig. 22. Testicle with surrounding inflammatory tissue, vas, seminal vesicle, and a portion of prostate removed.

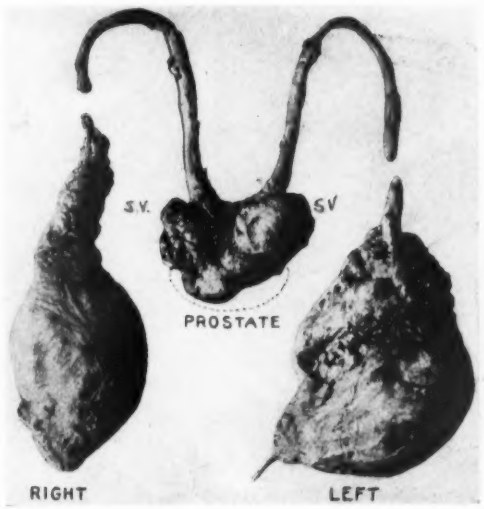


Fig. 23. Photograph of first total excision of seminal tract and part of prostate.

testicle is delivered (Fig. 17), the tunica vaginalis opened (Fig. 18), separation of vas and epididymis from veins and testicle carried out, and finally, division at the upper end of the epididymis made with a cautery (Fig. 19). After suturing the tunica vaginalis behind the testicle so as to avoid hydrocele formation, and after careful hæmostasis, testicles and veins are dropped back into the scrotum and the vas deferens, which has been exposed up to the external ring, is then freed from adhesions in its canal by a

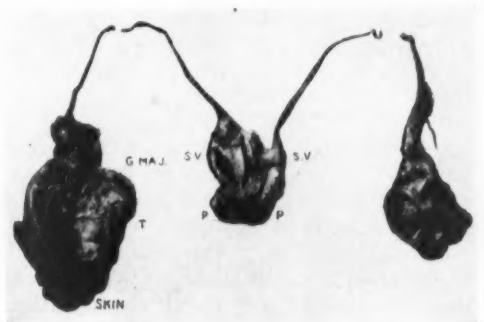


Fig. 24. Photograph of specimen from second case removed by suprapubic retrocystic extraperitoneal route.

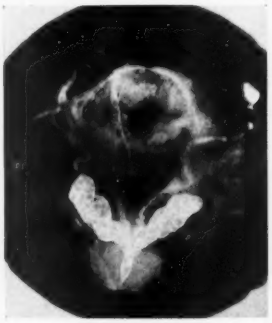


Fig. 25 (at left). Injection of vesicles with thorium. Roentgenogram showing tortuous cavities and impossibility of adequate drainage.

Fig. 26. Corrosion specimens showing multiplicity of cavities in vesicles.

to-and-fro traction (Fig. 20), produced by an assistant pulling upon the clamp (which we mentioned above as being left upon the lower end of the vas deferens), alternating with traction by the operator upon the vas deferens in the groin. In this way the vas is quickly freed, and, the assistant having liberated the vas from the clamp, the vas is easily drawn out in its entirety through the groin, as shown in the illustrations (Fig. 21). In this way we have a complete and radical removal of the entire seminal tract, with the exception of a few millimeters, the terminal portion of the ejaculatory duct, and we have also a conservative prostatectomy, leaving the urethra and bladder intact. This procedure, which is far more thorough and radical than any other which has been proposed, is carried out with great ease and is entirely under visual control. It is not our intention here to make more than a preliminary report, and case histories will not be given, but we can say that the results obtained have been extremely satisfactory and apparently radically curative in the majority of cases, some of which have been very extensive.

It has long been shown that very satisfactory results were obtained by nephrectomy in tuberculosis of the upper urinary tract, but occasionally the tuberculous ureter, which cannot be excised in its entirety, gives trouble, and tuberculosis of the bladder sometimes persists. With this radical operation for tuberculosis of the seminal tract, the removal is more complete and the results even more satisfactory than with nephrectomy.

The illustrations (Figs. 25 and 26) show first of all the impossibility of satisfactory drainage through the natural passages in cases of tuberculosis of the seminal vesicles and the ampullæ and epididymes. The tortuous, sacculated character of these structures is graphically shown in dissections, corrosion specimens, and X-ray photographs after the injection of thorium nitrate. It is, therefore, easy to see how both chronic inflammatory and tuberculous involvements are so resistant and the importance of operations upon the vesicles in both of these conditions is clear. The necessity of visual inspection in order to carry out a thorough operation, is also self-evident. The drawings depict the use of the long urethral tractor, the exposure obtained with it, and the various procedures which can be carried out upon the ampullæ, seminal vesicles, and prostate.

In a forthcoming paper I hope to present an array of case reports which will demonstrate conclusively the curative value of radical operations upon this deep-seated form of tuberculosis which has hitherto been considered beyond the satisfactory reach of surgery.

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CHOLANGIOGASTROSTOMY

With Report of a Case

By DR. RODOLFO E. PASMAN, Buenos Aires, Argentine
Interne, Rawson Hospital

SURGERY of the common and hepatic duct demands a perfect knowledge of the normal and anomalous anatomy of the region. It requires as well a knowledge of the pathologic modifications which result from different pathologic processes, particularly gall-stone complications. An operation to re-establish the common or hepatic duct is not very often done for it is considered fundamentally laborious and slow, and an operation which is liable to produce shock. Dr. W. J. Mayo[1] said:

> Operations for the restoration of the common bile-duct are usually of a formidable nature, not only because of the difficult technique but because of the poor condition in which these patients come to the surgeon. As a result of the former operation and combination of the local irritation, there are always extensive adhesions, and in these adhesions are an unusual number of thin walled veins which tear readily and flood the field with blood, or keep up a continuous oozing, thus adding to the difficulties of the operative procedure.

The majority of cases reported in which some surgical procedure has been carried out on the hepatic duct are those which have been operated upon for tumor, or chronic obstructions due to strictures or impacted stones. We find in cases of chronic compression of the duct, be it extrinsic or intrinsic, a dilatation above the obstacle, and because of this dilatation restoration by anastomosis with the stomach or duodenum becomes quite easy. On the contrary, when there has been a trauma producing a biliary fistula, instead of a dilatation of the duct being present, there is an area of intense irritation surrounding the ducts, and this makes the operation much more difficult.

Anastomosis of the duct with the duodenum, as done by Kehr,[2] Mayo,[3] and others;[4, 5] direct end-to-end suture, making a plastic (C. H. Mayo) or using a T tube (W. J. Mayo); end-to-end suture with resection of the narrowed portions; implantation to the duodenum of a rubber tube as suggested by A. G. Sullivan 1909,[6] but leaving a channel not covered by mucosa. Then, direct relation of both mucosae but using also a small tube. Our case was of this type but only an anastomosis between one of the right hepatic ducts with the stomach. But, as we had a big canal, and some very small ones, we put the rubber tube inside the big duct (4 centimeters) and made afterward the mucosa and all the corresponding portion of the wall of the stomach apply itself over this denuded area.

Very recently Drs. Ginsburg and Speese of Philadelphia[7] in plastic surgery of the hepatic duct have used a section of the posterior rectus sheath fascia including the peritoneum, this encircling the small rubber tube and becoming afterward the canal.

The history of the patient is as follows:

J. D., age 47, Argentine. She had a positive lues and pleurisy ten years ago, gall-stone symptoms five years ago. In her first attack she became icteric and had colorless stools. Afterward she had severe attacks. When she entered the hospital, she had a very painful zone in the right subcostal region. Diagnosis: cholecystitis. Through a Perthe's[8] incision, we reached a very small gall-bladder with retracted and altered walls, and with the omentum and duodenum adherent. Between the gall-bladder and the liver we opened a small abscess containing about 5 cubic centimeters of pus. From the bed of the gall-bladder to the hilus, we began separating the adhesions from the omentum, leaving in place those of the duodenum. Then we followed the technique advised by Moynihan,[9] searching for the pedicle and making a small rhomb, dissecting the peritoneum and subperitoneal tissue. (See illustration.) It was in making this dissection

[1] Collected Papers of the Mayo Clinic, 1915.
[2] Kehr. Chirurgie der Gallenwege, 1913.
[3] Mayo, W. J. Ann. Surg., Phila., 1905.
[4] Terrier. Soc. de chir., 1907.
[5] Gosset. Congrès de chir., 1908.
[6] Reconstruction of the bile-ducts. J. Am. M. Ass., 1912.
[7] Ann. Surg., Phila., 1917, January.
[8] Gray. J. de chir., 1914, 257.
[9] Abdominal Operations.

1, Liver; *2*, bifurcation of suprahepatic duct; *3*, hepatic duct; *4*, hepatic artery; *5*, dissected rhomb; *6*, duodenum.

that I damaged the hepatic duct. I afterward ligated separately the obliterated cystic duct and the cystic artery. On examining the common duct. I discovered a small hole in it. I attached no importance to this at first but to my surprise I found two other smaller ones just over the surface of the liver. This seemed to be the section of the right hepatic duct which had an immediate bifurcation after its starting from the hepatic duct. (See figure.) Kehr has made similar observations in 4 per cent of his cases. I think that on account of inflammation in the preperitoneal tissue, it was not a safe procedure to make a knife dissection over the hepatic area. Probably a small incision was done at first and then as the assistant luxated the liver by continuous traction, the section was made complete. At first, we could only see a very small opening in the right border of the hepatic duct. We found by the hepatic opening that the duct was permeable and a sound entered the duodenum without difficulty. We drained it and inserted in both suprahepatic ducts a 15 and 17 Nélaton rubber tube.

The three tubes were introduced in a larger one (Mayo). The three following days bile discharged through all of the tubes but in greater quantity from the one in the common duct. On the fourth day, I took out the two suprahepatic tubes, and on the tenth day the common duct tube. Until the twelfth day the patient had clay-colored stools; with a dose of calomel this changed but temporarily. Several days afterward the discharge continued, and the stools were almost completely clay-colored. The general state of the patient was very good.

June 20. We have made several attempts, following the technique of Kehr, to plug the fistula, but we succeeded only in diminishing the quantity of bile discharged. Twice the discharge stopped completely but the patient became chilly and feverish and her general condition was bad. There were but temporary clay-colored stools.

June 22. Second operation. Resection of the scar tissue. Omentum adherent to parietal peritoneum. I explored the fistulæ and then cut them so that the bile coming out would indicate the situation of the canals. The stomach, duodenum, and liver made a block of adhesions which were difficult to isolate. I separated the second portion of the duodenum (Kocher procedure) to secure better mobilization and to examine at the same time the retroduodenal portion of the common duct. The duodenum in its first portion was so adherent to the liver that I had to dissect a small portion of parenchyma to avoid doing damage to the duodenum. We then dissected over the zone of the pedicle, which was being made easy when we found permeable the foramen of Winslow. We had to "puncture" the portal vein to identify it and we made afterward a careful dissection of the common duct. We could see very well the hepatic artery and its bifurcation. The orifice on the common duct was found closed, the wall rather thickened, but seemed to be in good shape going on to the duodenum. The separation of adhesions had left a portion of the liver without its capsule and fluid bile was continually oozing. It was in this portion that we found one of our suprahepatic ducts. This was permeable to a No. 2 Nélaton rubber tube in a very long extension. Surrounding this orifice there was a limit of about 3 inches of a continuous bile oozing. Most of the discharge came from the other suprahepatic duct.

The following technique was used in restoring the bile-duct: A small tube was introduced 3 centimeters into the suprahepatic duct (represented as a small orifice) and then fixed by a fine chromic suture in the hepatic tissue. The tube was cut at a distance of 2½ inches. A purse-string suture was placed in the middle portion of the stomach and through a small opening the tube was introduced, closing without leaving tension over the tube. To avoid traction, the stomach was fixed to the upper portion of the gastrohepatic omentum, to the suspensory ligament, and also to liver tissue perforating the capsule of Glisson. We covered with omentum the portion of the liver that was denuded. Duodenum was replaced. The pylorus was well situated. The wound was closed with drainage. The relation of the middle part of the stomach with the upper portion of the hepatic duct makes this union much more practicable than union with the duodenum.

There was a discharge of bile for a few days. The patient took nourishment by mouth on the third day. On the sixth day, we found the wound in good shape and with small amount of bile discharging. From this day there were colored stools; sometimes they were of a whitish type, but never continually. On July 17, the patient was dis-

missed from the hospital. The tube has not been found. The X-rays were negative. We have made several gastric tests but have never found either salts or biliary pigments.

The patient has been seen every month, and now ten months after operation, her general condition is good but she is somewhat constipated. Well colored stools are passed. For the first two months after operation the patient complained of slight attacks of diarrhœa.

The damage was done just at the entrance of the suprahepatic duct which was abnormally bifurcated. What was the condition afterward? We had to deal with a small orifice laterally situated on the hepatic duct and two other ones over the hepatic tissue. More than half of the entire bile was discharged through these two openings. Should they have been shut off by ligature, should they have been drained, or should they have been sutured, using a Y tube? We thought it would be better to drain the bile as the patient was not in good condition, and this would shorten the operation. Also, we hoped that by tapering the openings to produce a different course, the bile would enter Vater's papillæ by only the left hepatic duct. We decided to use a triple drainage — a large tube in the common duct, and two small ones in both suprahepatic ducts.

The result was as feared and a double biliary fistula formed. The patient lost about 100 cubic centimeters of bile daily, though the opening in the common duct closed as usual. Periodically, the stools were a whitish color.

As I have already said we tried several times without result to prevent the bile from discharging. We placed pieces of gauze and cotton wrapped in rubber tissue in the canals but it was useless. However, it was very interesting to note that each time symptoms identical with those of bile infection developed. We had then to subject the patient to a new operation with the idea of restoring the suprahepatic duct. A direct anastomosis was impracticable on account of separation between the damaged canals and the hepatic; owing to the symptoms of infection that supervene so many times, we deemed it advisable not to try ligating the ducts.

We considered combining the Sullivan and Kehr procedures, using the Sullivan tube and at the same time making a direct mucosa union as in a cholangiogastrostomy.

Only one of the two orifices which were situated about one centimeter apart in the first operation was found in the second operation to have an explorative lumen. It did not appear as a real duct. We saw just a large orifice which admitted a sound for a great distance. The other orifice, as I have already stated, had a small lumen and the canal could not be explored. Anastomosis with the duodenum was not easy although we had separated its second portion (Kocher).

Is there any inconvenience in the emptying of bile directly into the stomach? Kehr, who has performed more than 60 cystogastrostomies and 3 choledocogastrostomies, speaks in favor of it. Employing the tube makes the technique much easier. The tube ought to be eliminated in a few days when the catgut is absorbed, thus leaving the canal formed. In that way the mucosa of the duct combines with the gastric mucosa. In our case the tube was not eliminated. X-ray examinations did not disclose the tube. We cannot tell whether the tube fulfilled its mission of hepatogastric communicant or if, on the contrary, an inflammatory process has taken place and the suprahepatic duct is completely obliterated, compelling the bile to be diverted by the left hepatic duct. We have made several test examinations at different hours in relation to meals but we have never found bile. This fact is very suggestive that the right suprahepatic canal is obscured. We must remember that at first we had two canals with quite large lumina, and that after 45 days, one of them was nearly occluded.

If we take into consideration the general good health of the patient ten months after operation, the stools normal and the patient not icteric, we must therefore accept the above conclusion or must assume that the bile is at present running a backward course and reaches the duodenum by the left hepatic duct, or we must assume that, on the contrary, notwithstanding the inability to demonstrate bile by stomach tests, there is a direct relation between the biliary system and

the stomach. The third consideration would be that a portion or all of the right lobe has become atrophic.

Nasse cited by Thoele[1] has done some experimental work along this line. He has ligated several times the left hepatic duct in dogs, and discovered that there was a shrinkage of the left lobe due to a diminished circulation in the portal vein branches. He observed a hypoplasia of the hepatic parenchyma with a hyperplasia of the connective tissue, and some small foci of necrosis. The right lobe presented a vicarious hyperplasia.

[1]Die Verletzungen des Lebens und den Gallenwege, 1912.

ELEPHANTIASIS TREATED BY KONDOLEON OPERATION[1]

By W. E. SISTRUNK, M.D., Rochester, Minnesota
From the Mayo Clinic

SEVERAL years ago Kondoleon of Greece described an operation which will probably occupy an important position in the future surgical treatment of lymphatic obstruction. His report of the results obtained by the method, and the case reports which have been published by several surgeons in this country who have used it (Matas, Royster, Hill, and others), have been sufficiently encouraging to make it appear that relief may now be offered to many patients of a class which formerly has failed to respond to the other methods of treatment.

Until this method was suggested we did not possess any means of satisfactorily dealing with many patients suffering with elephantiasis and lymphœdema, and in certain instances we had been compelled to resort to amputation in order to relieve such patients of the pain and discomfort accompanying these conditions. The operation which Kondoleon has suggested is a safe and simple one, and it is to be hoped that it will stand the test of further usage and prove itself to be a means whereby we may successfully deal with these stubborn conditions.

Prior to 1908, operations in which the large arteries were ligated and others in which large amounts of œdematous fat and hypertrophied skin were removed had been used but with poor success. In 1908 Handley suggested a method of operating for lymphœdema of the arm secondary to cancer of the breast which he termed lymphangioplasty. His operation consisted in the placing, subcutaneously, from the wrist to the normal skin around the axilla and shoulder, of long strands of silk. This was done with an idea of having these strands act as setons and drain the fluids from the swollen arm into normal tissues. His preliminary report was encouraging but later the operation was proved to be unsatisfactory and now is seldom used.

Lanz in 1911 reported the result obtained by a new type of operation which he had performed on a patient suffering with idiopathic elephantiasis. His operation consisted in making a long incision in the thigh exposing the femur and trephining this bone at several points. Strips of fascia were then carried down through the muscles and inserted into the openings previously made in the femur and the wound closed without drainage.

In 1912 Kondoleon, in a series of papers in which he gave credit to both Handley and Lanz for the work they had done in this connection, reported seven cases of lymphatic obstruction in which the patients had been operated on by the method now bearing his name. The operation was based on sound reasoning. He realized that the superficial and deep lymphatics were distinctly separated by the aponeurosis covering the muscles. His studies had shown that the œdema in such patients was usually limited to the subcutaneous tissues and fat lying between the skin and aponeurosis. By removing portions of the aponeurosis he hoped to connect the superficial lymphatics with those of the deep

[1]Presented before the Minnesota State Medical Association, St. Paul, October 11, 1917.

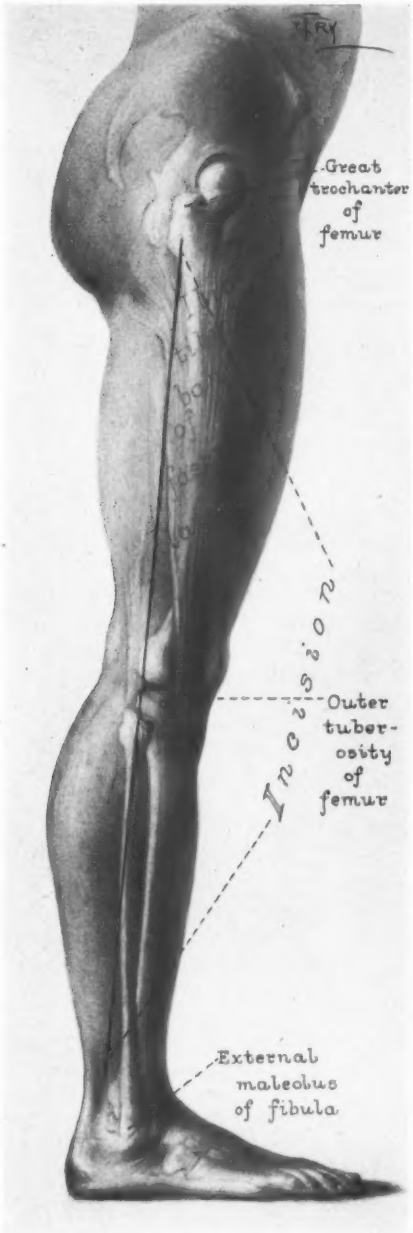

Fig. 1. Line of incision on outer surface of the leg and thigh.

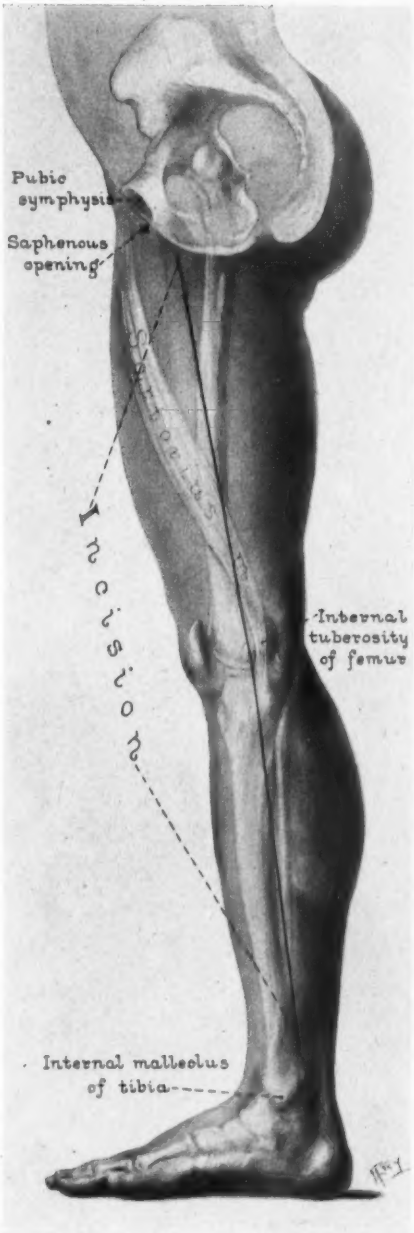

Fig. 2. Line of incision on inner surface of the leg and thigh.

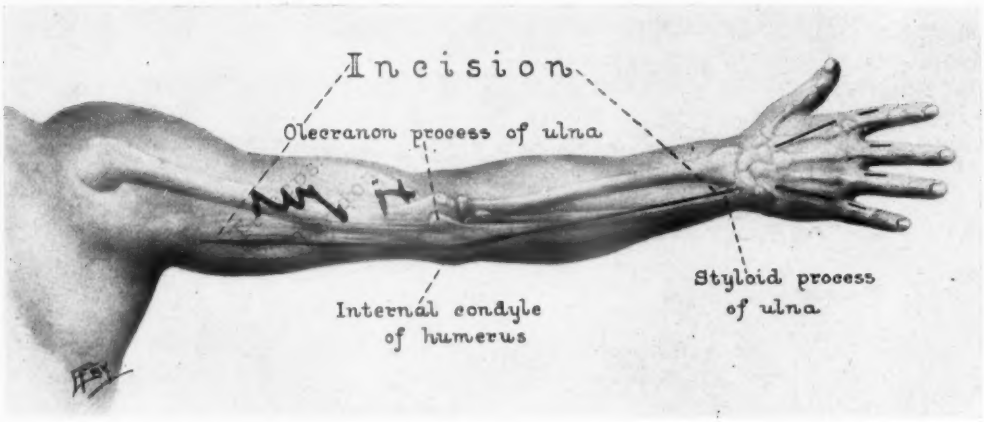

Fig. 3. Line of incision on outer surface of the arm and forearm.

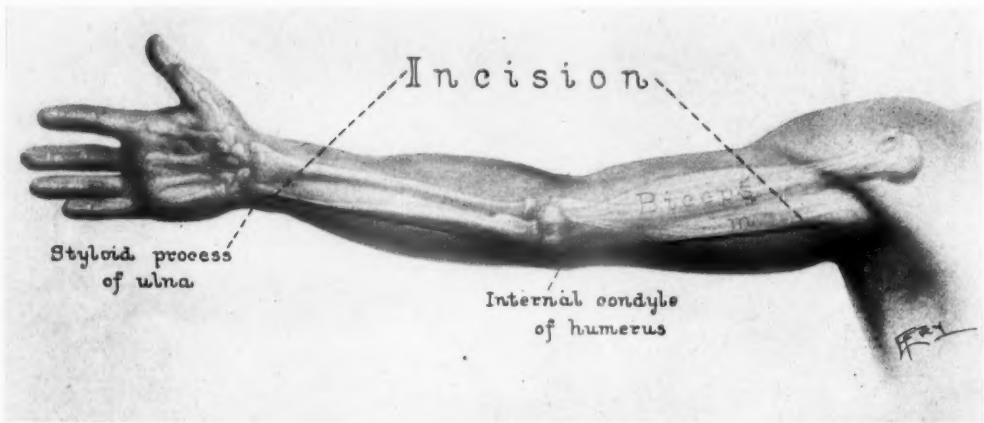

Fig. 4. Line of incision on inner surface of the arm and forearm.

group and in this way obtain drainage of the superficial structures.

In the group of cases which he reported various types of lymphatic obstruction are to be found. Four of his patients had developed trouble following infections, one after the removal of the inguinal lymph-glands; another was a patient with idiopathic elephantiasis and the last one a patient with an œdema of the arm secondary to a carcinoma of the breast which had been removed and had later recurred in the axilla. The results he obtained were uniformly good.

The technique of his operation is as follows: Long incisions are made along the inner and outer aspects of the affected limb and through each of these a large slice of œdematous fat is removed. The aponeurosis is then opened and a portion of it three or four fingers in width, is excised. The wounds are closed without drainage in such a way that the skin with the fat attached to it comes in contact with the exposed muscles (Figs. 1-5).

I shall report in this paper three cases in which the operation was done according to Kondoleon's method. Each of the operations

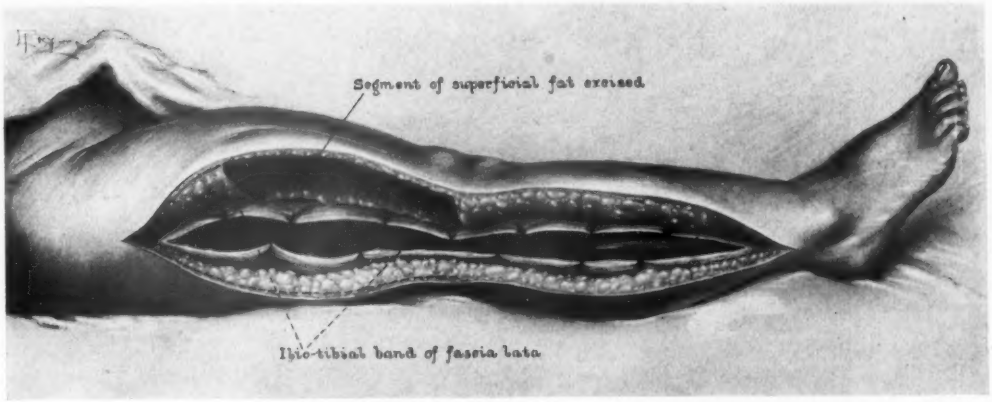

Fig. 5. Technique of Kondoleon operation. Aponeurosis has been incised, separated from the muscle and sutured in such a way as to allow the subcutaneous fat to drop on the muscles after the wound has been closed. A portion of subcutaneous fat has been removed.

was done in a different type of obstruction. In two enough time has not elapsed to know what the end-result will be but marked improvement has followed the operation in both cases.

CASE 41167. A female, aged 21 years with the congenital type of elephantiasis of the left leg, which had been present since she was one and a half years of age. When first seen in the Mayo Clinic the patient was fifteen years old. At that time there was a tremendous enlargement of the left foot, leg and thigh, and a marked thickening of the skin covering these. In August 1911, according to Handley's method, one silk strand was placed on the outer and one on the inner aspect of the leg, from the ankle to the region of the left groin. The patient returned six months later without improvement, in fact the enlargement had increased. In February 1912 a double silk strand was placed subcutaneously on the outer and inner aspects of the leg and the inner of these strands was extended upward into the fat of the abdominal wall while the outer strands were carried as high as the left axillary line. The condition remained unchanged until her return more than four years later. At this time, December 1916, an operation of the Kondoleon type was done, first on

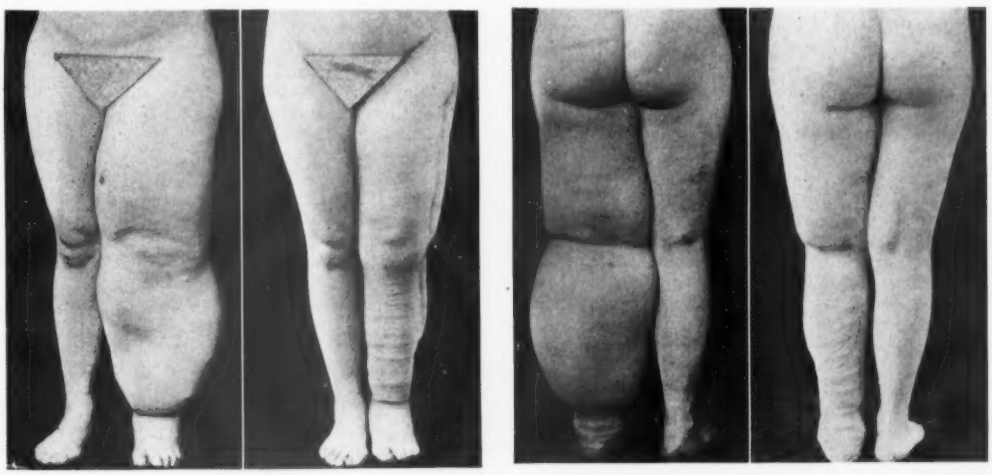

Fig. 6 (41167). Posterior and anterior views before operation and three months after operation.

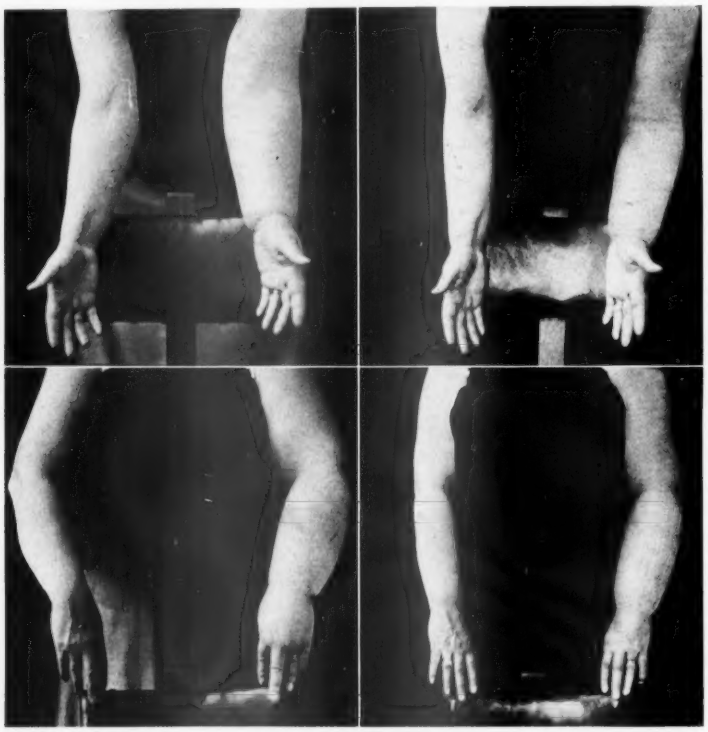

Fig. 7 (206558). Views of the arm before operation and two and one-half months after operation.

the outer side of the leg and about one month later, on the inner side. The improvement was marked from the beginning and at the time of her discharge, March 1917, the leg was much smaller than before the operation. Letters received since the patient returned home indicate that the leg has continued to diminish in size (Fig. 6).

CASE 170799. A female, aged 20 years with elephantiasis nostras. The history was negative until she was 11 years of age, when there was a severe infection following vaccination on the left arm. After the vaccination wound healed, she was in good condition until two years before coming to the Clinic. At this time swelling of the left hand had developed and had slowly progressed until the forearm and arm were involved in the process. She had many attacks of erythema in the swollen portion. The history and findings in this case have been reported in detail by Dr. Joseph A. Elliott.[1] At the time of our examination the patient presented a diffuse swelling of the arm, forearm, and hand. The swelling was more marked in the hand and gradually diminished up to a point a few inches below the acromian process. It also involved the proximal phalanges of the fingers. There was a definite thickening of the skin. July 13, 1917, an operation of the Kondoleon type was performed through incisions five or six inches long on the anterior and posterior surfaces of the arm and forearm. No incisions were made on the hand. Considerable improvement followed in the arm and forearm but the condition in the hand remained stationary. Some swelling also remained about the elbow. A second operation was done September 29, 1917, at which time two incisions were made on the dorsal surface of the hand and one on each of the lateral surfaces of the elbow. Multiple incisions were also made on each proximal phalanx of the fingers. Although but a short time has elapsed since the last operation the improvement has been quite noticeable (Fig. 8).

CASE 206558. A female, aged 51 years with lymphœdema of the left arm following amputation of the breast with removal of the axillary glands. The wound had not been infected. Two months after the operation the arm began to swell, growing

[1] Elliott, J. A. Elephantiasis nostras; review of the subject with report of a case. J. Cutan. Dis., 1917, xxxv, 17-25.

Fig. 8 (170799). Three months after Kondoleon operation. No operation was done on the dorsal side of the hand and the swelling has remained unchanged while the arm has returned almost to normal. Unfortunately no photograph was taken in this case before the operation.

slowly but progressively worse and involving the dorsal surface of the hand, the forearm and the arm nearly as high as the shoulder-joint. There was no thickening of the skin. September 1, 1917, a Kondoleon type of operation was done. Long incisions were made on the outer and inner aspects of the arm and forearm from a point a few inches below the shoulder-joint down to the wrist; also two incisions were made on the posterior surface of the hand. The swelling in the hand and arm decreased at once and at present (two and a half months after the operation) they are almost normal in size. There has been also marked improvement in the forearm but some swelling is still present. Should this persist it is possible that benefit might be derived through the excision of more of the aponeurosis (Fig. 7).

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AN UNUSUAL SKIN INFECTION DUE TO BACILLUS MUCOSUS CAPSULATUS ASSOCIATED WITH A BLADDER DRAINAGE AFTER PROSTATECTOMY

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MANY cases of bladder drainage through suprapubic incisions give evidence a few days later of a mild inflammatory condition of the surrounding skin. This inflammatory reaction is sometimes characterized only by erythema with slight subjective symptoms of burning and itching. Commonly also one finds a more severe type of reaction associated with the formation of papules and of a few pustules with more marked subjective symptoms. In the case here described, however, there occurred a type of inflammation of the skin which was characterized by the development of numerous small (3 to 8 mm. in diameter), nearly circular ulcers with necrotic bases, which discharged a thick glairy secretion resembling mucus. From these ulcers, on two successive occasions, a bacillus was obtained in practically pure culture which resembled the organism described by Fasching[1] in 1891 and called by him bacillus mucosus capsulatus. The appearance of the lesion, the recovery from it of the organism, the protracted clinical course, and finally its prompt healing after a single application of stick silver nitrate, were features so noteworthy that it seemed of importance to record them. The literature on infections with this organism is so scanty that I have been able to find the record of only one other case in which a skin lesion has been found associated with an organism resembling this one. That was in a case reported by Rolly[2] in which the Friedlaender bacillus was found in necrotic ulcers involving the perineal and sacral regions of a 26-year old woman who died within about three weeks, showing the organisms also in the blood. The bacillus mucosus capsulatus and the Friedlaender bacillus are now generally regarded by bacteriologists as the same, although they differ very slightly in certain characteristics.

Mr. H. R., aged 83 years, entered the hospital on April 24, 1917, because of inability to pass his urine. He had been unable to urinate for about twenty-four hours. His physician had made several attempts at catheterization but without success. He gave a history indicative of prostatic obstruction extending over a period of about fifteen years. During this time he had been compelled on several occasions to get relief by catheter. He had noticed that the urine frequently was milky in appearance. Examination revealed a greatly distended bladder; and through the rectum an enlarged prostate could be made out. Attempts at catheterization with Mercier catheters failed, and accordingly, under novocaine anæsthesia, a suprapubic incision was made and a tube inserted into the bladder. About a quart of urine escaped which contained a moderate amount of pus. At the same time a large prostate was detected.

Notwithstanding the advanced age of the patient it was decided to remove the prostate at a later time if his general condition should warrant it. He improved rapidly after establishing the suprapubic drainage. He was able to be up walking around within a few days; and his temperature, which had been 101.2° on admission, had returned to normal. On May 17 his urine was slightly acid and contained only microscopic pus. A functional test with phenolsulphonephthalein showed the first appearance of the dye in 9 minutes; in the first hour 20 per cent appeared and in the second hour 15 per cent. Because of earnest solicitation on the part of the patient it was decided to attempt the removal of the gland on the following day. With novocaine anæsthesia the old opening into the bladder was enlarged; but because a large amount of pus was found in a sacculation of the bladder it was considered advisable to postpone the enucleation of the prostate for a few days. The bladder was, therefore, merely irrigated and tubular drainage re-established. On May 23, under novocaine, the incision was again opened, and with the aid of a little ether the prostate was enucleated; total duration of operation was 17 minutes. The prostate was found to be a large adenoma. Microscopically there was no evidence of malignancy.

During the following week the convalescence was normal in every way. But on May 29 for the first time it was noticed that the edges of the wound

[1] See Kolle and Wassermann: Handbuch der Pathogenen Mikroorganismen, 1913, vi, 534.

[2] Beitrag zur Klinik durch den Bazillus Friedlaender erzeygten. Sepsis. Muenchen. med. Wchnschr., 1911, lviii, 17.

contained much necrotic tissue and that three or four circular ulcers, such as have been described above, were present in the skin in the immediate vicinity of the incision. There was also observed the characteristic glairy mucoid secretion. From this time on the condition of the wound became worse. The edges were covered with a thick layer of necrotic tissue, and the closure of the wound was greatly retarded. The circular ulcers adjacent to the wound increased greatly in number and the intervening skin was erythematous. There were no subjective symptoms other than burning and smarting. The temperature remained normal and the general condition of the patient was excellent. Eight days after the prostatectomy he was up walking around with his clothes on and remained able to do this until his discharge from the hospital. The highest leucocyte count was 12,500. On two different occasions the organism to be described below was obtained from the necrotic tissue at the base of the ulcers and from the mucoid secretion.

Various means were used in an attempt to promote healing and check the progress of the inflammation, such as hot dressings, frequent cleansing and irrigation with and without various antiseptics such as alcohol, bichloride, and boric acid, and frequent application of iodine to the ulcers. None of these measures appeared to have any effect whatever. Finally, on June 27, after nearly a month of no apparent progress in healing, each of the ulcerated areas was cauterized with stick silver nitrate as were also the edges of the incision. On the following day there was no longer any discharge of mucoid material and no new ulcers. Within five days the wound was entirely closed and the patient was urinating in the natural manner. He was discharged July 2.

The organism which was found and identified as the bacillus mucosus capsulatus by Miss Helen Peck presented the following characteristics: On agar it was short with rounded ends, length about three times as great as width, approximately 3 microns. It was seen singly and in groups but with no chain formation. It stained readily with aniline gentian violet and methylene blue but did not stain with Gram's method. It was non-motile, and no spores were observed. It grew abundantly at 37.5° C., was aerobic and produced no pigment. It fermented dextrose and lactose but not saccharose. After 24 hours 25 per cent of the dextrose had been fermented and 10 per cent of the lactose. There was no additional change after 48 hours. The reaction in the fermentation tubes was alkaline. Milk was made alkaline and was coagulated in 48 hours.

Fig. 1. Photograph of lesion. *A*, Glairy mucoid secretion in incision; *B*, typical ulcers.

After about 3 days the milk became neutral. There was a markedly fetid odor in all media similar to the odor noticed about the patient. There was no indol production. On blood agar there was a profuse, slimy, grayish growth which was irregular, moist, and slightly raised. At first the growth was only along the line of inoculation but later it was spread over the entire plate. There was no hæmolysis but marked discoloration of the media after 48 hours. Intradermal and subcutaneous injections of the organism into guinea pigs produced no lesions.

A piece of tissue excised through one of the ulcers showed under the microscope only simple inflammatory tissue, chronic in type. There were relatively few polymorphonuclear leucocytes, but a large number of plasma cells and a considerable number of eosinophiles. The leucocytic infiltration was present chiefly immediately beneath the Malpighian layer. An occasional bacillus was found in sections adjacent to necrotic tissue.

SUMMARY

A peculiar ulcerative lesion of the skin following a suprapubic prostatectomy in a man 83 years of age was found to yield an organism resembling the bacillus mucosus capsulatus. After running a clinical course of over three weeks with no improvement, it responded quickly to a single cauterization with stick silver nitrate.

IMMEDIATE SURGERY OF GUNSHOT WOUNDS OF THE CRANIUM

Reviewing Forty-Six Recent Craniotomies Performed within a Few Hours After the Reception of Wounds

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INVESTIGATION of scalp gunshot wounds is practically a routine procedure in war surgery when time and facilities are given. In a trial series of 25 harmless-appearing gunshot scalp wounds, the author found three fractures upon investigation. In casualty clearing stations, even the most experienced surgeons admit an inability to make positive statements in all instances of head wounds, and the roentgenograms required are either too numerous to be taken, or their findings are often too unsatisfactory. Close inspection by the surgeon after scalp excision is necessary. If excised, such simple scalp wounds heal rapidly and cleanly, and are a satisfaction to patient and operator. Local or general anæsthesia may be employed.

For the immediate surgery of head gunshots, the author refers, of course, most particularly to war wounds, and the services rendered by the trained and ever ready surgical teams of casualty clearing stations, and the preliminary examination of the patient must be considered a part of the general technique. Men arriving in coma from head injuries, or with hernia cerebri or gross cranial lesions, are prepared at once for operation, if their general condition warrants. If it does not, they are warmed, stimulated and cared for in a resuscitation ward until in condition fit for surgical procedure. Operable patients are sent to pre-operation wards for head shaving, later for roentgen examination if penetration is found without exit, regardless of symptoms. A rush of work may forbid this most helpful accessory examination, so that only deeply penetrating wounds with severe symptoms can be subjected to localization. The operator's experience and skill are depended upon to aid him in subjects not X-rayed.

A general description of technique may suffice for the usual operative steps and save repetition in more detailed pathology. Scalp excision is made one-quarter to one-half an inch wide of contused edges, disregarding the amount of tissue which must be sacrificed. Unhappily war wounds have no respect for cranial topography; consequently a scalp tourniquet cannot always be used. Large scalp hæmostats with small clamping area and long handles, which really are an aid in retraction, minimize the bleeding. This hæmorrhage is often free but seldom causes worry. Soiled and tousled pericranium is removed with the scalp, or is scraped away with a periosteotome if necessary, to avoid infectious thrombosis of emissary veins, a fertile source of meningitis and septic sinus thrombosis.

Bone puncture, or depression of the inner table, except the smallest scratches, require investigation. Trephining or chipping away of both tables with small rongeurs is required to determine the state of the inner table and extradural space. It is best not to use the chisel and mallet on the skull, although there is no valid objection to sharp, small gouges and wooden mallets. When the dura has not been punctured, it is questionable whether it should be opened in a field of unknown asepsis. Subdural clots which remain sterile frequently absorb with no ill effect. Should intracranial increased tension necessitate decompression, it is best done in a clean area remote from the gunshot wound. Shrapnel and bullet traumatic effects on cranial bone and brain tissue may be different on account of the twirling induced by rifled bores. Bone lesions caused by bullets may be correspondingly greater to the inner table or brain track and require more thorough investigation. This rule applies particularly to gutter wounds.

A constant irrigation stream of hot normal salt solution keeps the operative field clean,

washes out clots, small bone and other foreign body fragments and partially controls hæmorrhage. Such mechanical cleansing of exposed cortex should be encouraged. If the dura is contused or tousled, it is excised sparingly, the bone excision being made large enough to give a margin of this healthy tissue within its edges. Bone excision is minimized but *must* include provision for removal of the severely comminuted and dirtied area and for sufficient dural excision. After these steps, there is quite constantly seen a rushing forth of lacerated, softened cortical material and clot from the cranial opening. All is swept away by the flushing of normal salt. If the foreign body is relatively superficial, it is felt by a small blunt scoop or curette or by the finger inserted daintily into the brain track. Bone fragments may be mistaken for the metallic foreign bodies. The author has found wood splinters and in one instance a stone the size of a robin's egg embedded in the brain. (See description of Patient No. 13 which follows.)

The operator may irrigate with the stream of solution directly into large and deep tracks of the brain; bone fragments and disorganized brain will frequently float out bringing with them infectious material. Usually the metal carries in infectious hair, scalp, or cloth. Consequently from the standpoint of later infection and cerebral irritation, the patient is offered a better prognosis if the metallic foreign body is removed. There is some dispute about the relative irritative power of metal and of bone fragments which are showered down along the track made by the missile. These bone fragments are reasonably sterile; we expect the most of the cloth and external infectious surfaces carried in, to progress with the metal, a clinical finding proved beyond doubt in gunshots of other parts of the body. Roentgenographic plates in brain penetration will seldom fail to discover this bone shower, some fragments being frequently scattered out at an angle from the main wound track. From an operative standpoint in some instances it may be considered a technical *faux pas* to attempt their removal, but they may cause irritation by their presence. The author believes that those washed out or easily drawn out are better removed, but brain damage attempted in eliminating very deep or widely scattered bone fragments may not be compensated for by the material obtained. It is to be anticipated that this bone will be absorbed if recovery follows, as is non-functionating bone in any tissues of the body.

Foreign bodies in accessible regions which are localized or palpable can be coaxed out with a dull spoon. When metallic and very deep they may be drawn out by the electromagnet, the sterilized obturator being first passed to the foreign body and the magnet attached by a ball and socket connection before the current is turned on. Jumps and jars of the quickly attracted metallic body within the brain are thus obviated. When the metal has traversed the skull beyond reach, as down into the basal fossæ, or the track passes perilously near large intracranial vessels or the sinuses, the most delicate manipulations are necessary to avoid hæmorrhage; although the operator may be loath to give up the search, it is better to take no risks and depend on track cleansing without foreign body removal.

In one patient (Case 18) the author was enabled to palpate both the torcular and straight sinus, to make sure of their non-injury, and to remove a sizable piece of metal from a position just in front of their junction.

Complete closure of the scalp with or without capillary drainage at one angle of the wound is the last operative step — and one of the most essential following craniotomy. The excised wounded dura can very rarely be approximated. The scalp can be dissected widely from the pericranium, so that it stretches and permits closure of large defects. On the whole, the pericranium should not be removed from the healthy bone surrounding the wound. If the scalp fails to meet over the denuded bone without undue tension it may be slipped over by parallel or curving incisions made at some distance, the intervening scalp being dissected completely free from pericranium beneath. In some instances, flaps need to be turned in over defects, or the employment of radiating

incisions will permit closure. The operator must devise a method to meet every demand. Little attention need be paid to bare areas of pericranium remote from the bone and dural defect after plastic closure; they will granulate over and seldom form an atrium for infection of the distant wounded cortical surface. Following the trimming and irrigation described, it is infrequent to find a tendency to hernia cerebri after the early operations.

Postoperative treatment consists of at least ten days' complete rest in bed before removal to the base, with the exhibition of bromides in sufficient doses to insure mental quiet. If scalp infection or edge sloughing develops, antiseptic dressings are indicated.

An examination of the records of the 46 patients on whom craniotomy was performed following gunshots resulting at least in bone lesion disclosed the following facts:

Number of cases	46
Deaths	9
Mortality per cent	20

Classification made for statistical study of the whole number:

	No. of Cases	Deaths
Middle meningeal hæmorrhage	6	1
Bone sinus injuries	5	1
Blood sinus injuries	4	1
Mono- or hemiplegias	5	1

One patient recovered from his hemiplegia.

Aphasia	
Patients with penetration of brain by the foreign body	24

	No. of Patients	Recoveries	Deaths
Foreign body removed (or passed out)	13	12	1
Foreign body not removed	11	6	5

Mortality comparisons as to site of wounds of entrance:

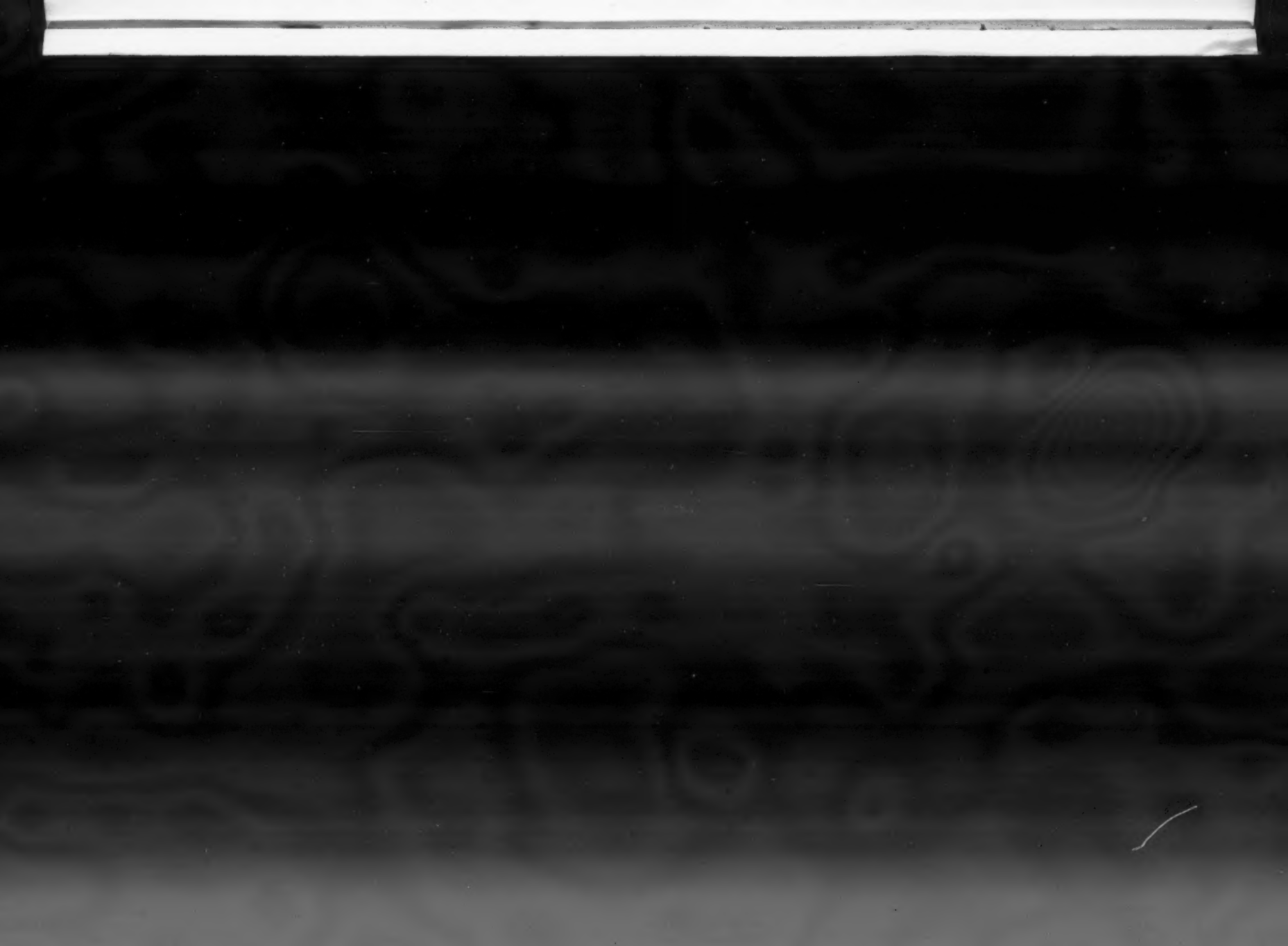
	No. of Patients	Recoveries	Deaths
Frontal areas	6	5	1
Parietal and temporal areas	15	11	4
Occipital areas	3	1	2

A former observation of the author on a series of 75 gunshot fractures of the skull in a base hospital [1] of which 36 were operative, gave a mortality of 46 per cent. The results of this series of early craniotomies seem to have given a mortality less than half of that, a valid argument in favor of early interference. The series is small numerically, but as in all branches of operative surgery, the work of one operator must alone be weighed to arrive at sensible comparisons. None of these cases operated upon early developed epilepsy while under observation, but bromides were given as a routine to all who could take them. The author still believes that occipital wounds offer the poorest and frontal the best prognosis on the whole. Considering the variance in mortality where foreign bodies are removed and left in the brain, one is inclined to advocate again their *early* removal. The factor of inaccessibility of foreign bodies must be considered in weighing statistical mortality, and may frequently be the reason for non-removal. Under these circumstances, the injury can be anticipated to be more serious and a higher mortality feared, so that statistics fail ultimately to tell the story. From the observation of these head wounds, on his own service, and of those of several other surgeons at the clearing stations, the author believes that much dreaded hernia cerebri seldom follows early operation.

Middle meningeal hæmorrhage was encountered six times, with only one death, after operation and ligature. Three of these cases sustained depressed fractures of the skull. It would be reasonable to expect that a much higher mortality would have followed non-interference or delayed operations. All the patients except one presented clean-cut symptoms of the condition. One interesting instance of middle meningeal hæmorrhage may be cited:

Patient No. 28, Pte. W. F., 75 S.A.M.C., had five gunshot wounds of the head. Of interest was one over the right ear, penetrating the brain through a depressed fracture, the wound of entrance being but a small slit in the scalp three-quarters of an inch long. After exposure of the skull, oozing brain substance was seen, and beneath the skull was found the meningeal hæmorrhage, which necessitated tying the middle meningeal artery. On following the track into the brain the foreign body was felt at a depth of two inches. There was much surprise on its removal to find that it was a small oval-shaped

[1] Speed. J. Am. M. Ass., lxviii, 1299.



stone, three-quarters of an inch long, which had evidently been blown in. The magnet, of course, would not effect removal. The patient's right arm had been blown off and because gas infection was present, a high shoulder amputation was demanded. Recovery followed.

Bone sinus injuries were found five times. The frontal and mastoid sinuses were involved. When this complication is present with brain injury, it seems wiser to perform an early radical operation to avoid possible infection from the sinus lining. There was only one death in this group of patients, that undoubtedly influenced by the presence of other wounds. When the frontal sinus connected with the wounded cortical area it was considered best to remove carefully by gentle curettage all mucous surface and to leave small drains to the depth of the sinus.

With four instances of blood sinus injury, there was but one death. These sinus injuries are extremely interesting on account of the tremendous hæmorrhage which arises when depressed bone adherent to the sinus wall is removed. On the whole it appears better to leave depressed bone alone under these conditions and to prefer to take a chance on subsequent septic sinus thrombosis rather than to excite an uncontrollable hæmorrhage. Gauze packings or packing with a piece of muscle belly removed under sterile precautions from another part of the patient will sometimes control the bleeding quickly. Another technical possibility lies in inserting fine stitches in the dura about the area which threatens hæmorrhage. A suitable piece of fascia lata with muscle adherent on the under surface is prepared from the patient's thigh. One end of each thread of the dural stitches is then caught around the edge of the transplanted fascia and muscle at proper intervals, the depressed bone is removed, and if hæmorrhage follows, the transplant is rapidly tied into place to control the leakage. The symptom of generalized muscular rigidity, so indicative of blood sinus injury, was present in two of these patients.

Partial aphasias were quite common. They were for the most part motor (ataxic) and less often sensory. No instances of optic amnesic aphasia nor auditory aphasia (word-deafness) were encountered. As expressed elsewhere the author still has doubts about the validity of Broca's speech center in the left third frontal convolution. All instances of aphasia made rapid improvement while under observation, and promised ultimate recovery.

Patient No. 18, G. R., 5193, L/Cpl. sustained a bomb wound of the head, fracturing the skull and penetrating the brain. The author happened to be on duty at the time and saw the enemy plane which dropped the bomb. The patient was received very quickly. After exposing the skull and trephining, it was found that the foreign body had penetrated deeply across the base of the brain. The track was irrigated and the finger was unable to palpate the metal at the fullest insertion. While under surgical anæsthesia and apparently deeply relaxed, the patient had two severe general convulsions on the operating table, following the digital exploration. He made a recovery and never had any postoperative convulsions. Captain Dale, M.R.C., U. S. A., made an effort to control these at the time of occurrence by pushing the anæsthesia to the limit, but was unsuccessful.

Patient No. 46, J. P., 816, 13 I.R., Prussian, German prisoner, sustained a gunshot fracture of the right side of the head, extending from the posterior temporal region almost to the midline of the vertex, which blew away considerable cortical surface and gouged a deep gutter in the brain. The wound was completely trimmed and the scalp tightly closed. He made a most rapid uncomplicated recovery, a fact which spoke very well for his resistance and state of health.

Patient No. 45, C. W. C., 1814, Cpl., R.E., among other wounds, seven in all, sustained perforation of the brain via the left occipital region. The X-Ray plate showed the foreign body behind the left orbit. On following the track through the occipital region, it was found to lead directly through the lateral ventricle. The missile was not secured. Recovery.

Patient No. 13, B. W., 44275, Pte., gunshot wound right temporal region, penetrating, with a foreign body lying in the occipital region about the midline within the skull. On following this track the torcular and straight sinus were both palpated at the end of the index finger five and one-half inches deep, and the foreign body was removed from just in front of them. The patient made a recovery; was under observation seven weeks; and has since written a letter from England.

THE TREATMENT OF SEPTIC ABORTION[1]

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DURING the years 1914 to 1916 and up to the present time the treatment of septic abortion in the gynecological ward of Michael Reese Hospital has been conducted during the months of my service according to principles which are not yet generally accepted. It has, therefore, appeared worth while to submit to discussion the principles underlying and the results following this line of treatment.

In order to have a clear understanding of the problem in hand it may be wise to state specifically what we have called septic abortion.

We have called for short an abortion every premature delivery up to about the sixth month. We speak of treating a case of abortion only when the birth of fœtus and placenta or at least the birth of the placenta, naturally or operatively, takes place under our care. Furthermore we call such an abortion a septic one, if it is accompanied at any time during its course by a rise of temperature to at least 100° F. One hundred is, of course, entirely arbitrary, but we have to draw the line somewhere and one hundred has been used as a convenient starting point by many authors on this topic.

It is clear from this limitation that a case, for instance, which after abortion without any temperature subsequently shows chills, or fever or parametritis or pus tubes or general sepsis or pyæmia or peritonitis, etc., is not a case of septic abortion in the sense of this discussion, but a case of puerperal sepsis, sepsis following abortion.

Also, if a case is diagnosed abortion and some tissue is removed by some operation and the microscopic examination of that tissue shows no trace of any product of pregnancy (including decidua), then the case is not a case of abortion and if it had fever, it was not a case of septic abortion.

It might appear to be more scientific to make the diagnosis of septic abortion depend on bacteriologic findings, but from the study of the literature of this field of work, the present status of this means of diagnosis appeared so hopelessly confused that I preferred the above outlined definition. Work based on this clinical definition appeared especially worth while since it could serve as a simple guide to the obstetrician in everyday practice.

Septic abortion then means abortion and sepsis at the same time and, we may add, sepsis located in and spreading from the sexual tract. If a patient has an abortion together with a septic peritonitis from a perforated appendix or gall-bladder that would not be a septic abortion but an abortion and sepsis. However, none of this class of cases was observed during the period mentioned.

The treatment of septic abortion is always dominated by two opposite theories. One theory teaches that the presence of all or part of the product of pregnancy in an infected uterus is a serious complication of infection and makes that infection a specially vicious sort of infection. This theory also insists that the cure of the septic abortion necessitates the removal of all placental tissue.

The other theory, represented especially in recent years by Winter, teaches that the infection is a matter independent of and not especially affected by the presence of all or part of the product of pregnancy in the uterus. The hæmorrhage which is liable to occur in the case of abortion, according to this standpoint, is a matter *per se* which may influence the course unfavorably by causing anæmia, thereby lessening resistance, and may require treatment on its own account.

The difference of opinion in this regard is the same as exists today and especially has been prevalent in years past in the matter of treatment of puerperal sepsis. Especially in years gone by, the search for remnants of placenta in an infected uterus has been an essential part of the treatment of puerperal

[1] Read before the Chicago Gynecological Society, June 18, 1917. (See discussion, p. 469.)

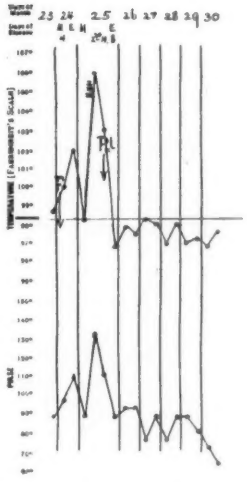

Chart 1, Case 1. *F*, fœtus; *Pl.*, placenta; ↓, passed; ⊟, chill.

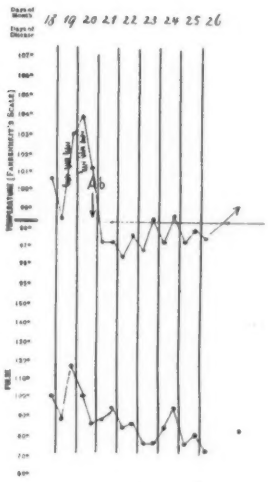

Chart 2. *Ab*, abortion completed; ⊟, chill; →, patient discharged.

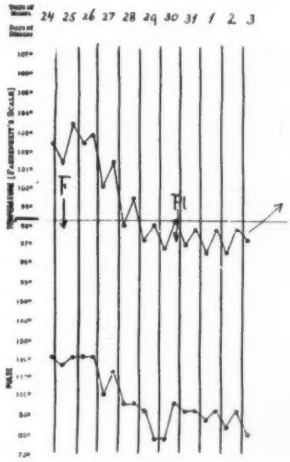

Chart 3, Case 2. *F*, fœtus; *Pl.*, placenta passed; →patient discharged.

sepsis. I may claim to have been among the first to combat this treatment as based on erroneous conceptions of pathology. I have contributed to the literature of the subject in 1909[1] in this sense. I have had no reason to change my attitude in this question and have had the pleasure to see the majority of the advanced workers in gynecology come to join me. While the active search for placental remnants in the uterus in all or the majority of cases of puerperal sepsis was the treatment in vogue years ago, the teaching largely accepted now is: Hands off the septic puerperal uterus except for serious hæmorrhage!

In the treatment of abortion, however, there is still a vast divergence of opinion. While some gynecologists advise active interference in every case of abortion, septic or not, others are more conservative. Few, indeed, are the operators who will leave an inevitable or incomplete abortion to nature, and the textbooks have little to say in favor of the expectant treatment in the case of abortion, while they are most positive in the praise of the expectant treatment of labor at or near full term.

I can see no reason why in the absence of serious hæmorrhage or protracted slight hæmorrhage, an abortion should not be treated as conservatively as labor at or near full term. In the series of 156 cases of abortion which were observed under my care during the years 1914 to 1916 and which serve as the basis of this communication five cases were observed which had spontaneous abortions. None of these had fever or any other complications during or after the abortion.

CASE 1. Pregnant 6 months, bleeding 3 days, aborted one half hour after admission.

CASE 2. Pregnant 3 months, bleeding 3 days, aborted 24 hours after admission.

CASE 3. Pregnant 4 months, bleeding 12 hours, aborted on admission.

CASE 4. Pregnant 3 months, bleeding 24 hours, aborted 48 hours after admission.

CASE 5. Pregnant 5 months, bleeding 9 days, aborted 3 hours after admission.

Five cases out of a total of 156, about 3 per cent, aborted spontaneously, a small percentage certainly, but one not to be overlooked.

As to septic abortion there is a general impression that it cannot or must not be allowed to proceed spontaneously.

Williams in his *Obstetrics*, 1912, teaches "the uterus should be emptied promptly." He has a mortality of 28 per cent in his streptococcus cases.

[1] Physician and Surgeon, Ann Arbor, 1909.

Edgar in his textbook, 5th edition, says: "If the fœtus has been expelled from the uterus, the membranes and placenta remaining behind, the indication is to curette at once."

In the face of such statements it was, therefore, essential to find out the course of septic abortion if left to itself.

We have had six cases of septic abortion which have terminated spontaneously, 4 per cent of the total 156. Our total number of septic abortions is 21. These 6, therefore, represent 28 per cent. As these cases form the fundamental justification of our line of treatment I may be allowed to report them briefly:

CASE 1. Pregnant 6 months. Hæmorrhage 12 hours before admission, on September 23. Temperature on admission 99.4°; pulse 88. September 24, in the morning, a fetid fœtus was expelled spontaneously. Temperature 100.6°; pulse 96. In the evening temperature 102.6°; pulse 108. September 25, a.m., temperature 99°; pulse 88. At 2 p.m., chill, temperature 106.6°; pulse 140. At 4 p.m., temperature 103.6°; pulse 120. At 4:30 p.m., the placenta was expelled spontaneously. On September 26, highest temperature 97.6°; pulse 88. Puerperium without rise of temperature. Complete recovery. (See Chart 1.)

CASE 2. Pregnant 2 months. Hæmorrhage 2 days after patient herself introduced a catheter into her uterus. On admission March 24, temperature 103°; pulse 120. March 25, temperature 102°; pulse 116. Fœtus was expelled in the morning. In the evening temperature 104°; pulse 120.

There was slight hæmorrhage for the next 3 days. Temperature on the 26th, 103°, pulse 120, in the morning: p.m., 103°, pulse 120. On the 27th, temperature, a.m., 100.8°; pulse, 100, p.m., temperature 102°; pulse 112. On the 28th temperature a.m., 98.8°; pulse 96: p.m., temperature 100.2°; pulse 96. On the 29th temperature, a.m., 98°; pulse 92: p.m., temperature 98.8°; pulse 78, no hæmorrhage. On the 30th, a.m., temperature 97.6°; pulse 78: p.m., temperature 99°; pulse 96. The placenta was passed spontaneously. Temperature afterward 98.6°; pulse 72. No further rise of temperature, complete recovery. (See Chart 3.)

CASE 3. Pregnant 4 months. Hæmorrhage one month, severe for the last 5 days. The uterus contains a small fibroid. On admission April 21, temperature 99.2°; pulse 88. April 22, a.m., temperature 99°; pulse 76: p.m., temperature 98.4°; pulse 84. April 23, a.m., temperature 97.8°; pulse 80: p.m., temperature 98.6°; pulse 96. Membranes ruptured. April 24, a.m., temperature: 97.8°; pulse 94: 4 p.m. temperature 100.8°; pulse 112: 8 p.m. temperature 102°; pulse 112: 11 p.m. fœtus and placenta are expelled. Midnight temperature: 103°; pulse 136. April 25, a.m., temperature 97.8°; pulse 92: p.m., temperature 98.6°; pulse 88. Normal puerperium afterward.

CASE 4. Pregnant 5 months. Hæmorrhage one day. Admission April 13. Treated expectantly. No rise of temperature until April 17; a.m., temperature 97.6°; pulse 90. 10 a.m., fœtus and placenta expelled spontaneously. At noon temperature 100°; pulse 108. 4 p.m., temperature 99.6°; pulse 102. April 18 temperature a.m., 98.6°; pulse 80. Normal puerperium, complete recovery.

CASE 5. Pregnant 2 months. Chills, fever for 5 days previous to admission on June 18. On admission temperature 101.2°; pulse 100. On June 19, a.m., temperature 99.2°; pulse 88: p.m., temperature 103.6°; pulse 116. Three chills. On June 20, a.m., temperature 104.4°; pulse 100. Three chills. A mass of clots and placenta was passed. P.m., temperature 97.8°; pulse 86. On June 21, a.m., temperature 98°; pulse 94. Normal recover. (See Chart 2.)

CASE 6. Pregnant 3 months. Hæmorrhage one day. Packed before entering hospital on May 19th with a temperature of 101°; pulse 88. May 20th, packing removed. Spontaneous and complete abortion. In the evening temperature 99.8°; pulse 88. May 21, a.m., temperature 99.4°; pulse 88. Normal recovery.

To summarize: Six cases pregnant from two to six months with temperatures before or during the abortion ranging from 100 to 106.6°, two of whom had chills during the abortion, one of whom had produced a criminal abortion on herself, one of whom had been packed before admission, were in the hospital one to six days under expectant treatment and completed their abortions spontaneously with complete recovery without any temperature following the abortion.

The observation of these cases certainly justified the attempt to carry out the expectant treatment in cases of septic abortion. This treatment was carried out in all our cases of septic abortion, until some indication forced the abandonment of our passivity.

Among our 156 cases of abortion of this series we have had in addition to the six cases described, fifteen others which had temperature of 100° or over in the course of the abortion in which the expectant treatment was carried out. In these 16 cases it was observed that if the expectant treatment was carried out the temperature always dropped to normal if sufficient time was given and that if after the temperature

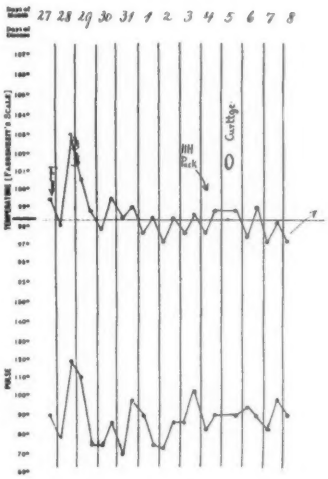

Chart 4, Case 7. *F*, fœtus passed; *H.H.*, severe hæmorrhage; *O*, operation; *Pack*, packing removed; ≦, chill.

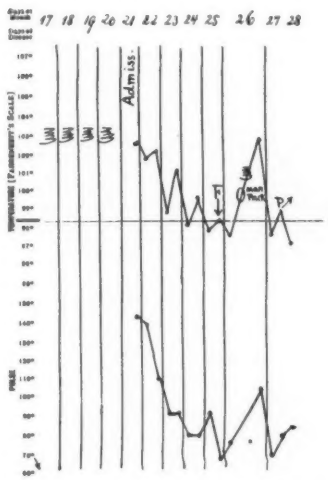

Chart 5, Case 8. ≦, chill; *F*, fœtus expelled; *O*, operation; *Man.* manual removal; *P*, packing removed.

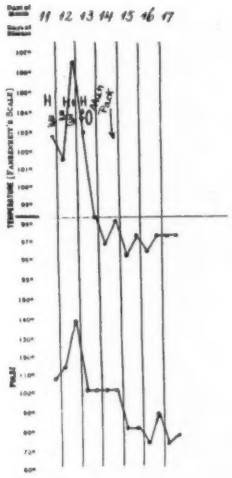

Chart 6, Case 10. *H.H.* + *H.*, increasing hæmorrhage; ≦, chill; *O*, operation; *Man.*, manual removed; ↓, removed.

had dropped to normal, the uterus had to be emptied on account of severe or protracted mild hæmorrhage this operation could be carried out without causing rise of temperature or at least with very slight and short reaction.

Typical cases of this kind may be reported briefly:

CASE 7. Pregnant 2 months. Hæmorrhage one day before admission on May 27, with temperature of 100°; pulse 88. Fœtus was expelled the same day. May 28, a.m., temperature 98.6°; pulse 76: p.m., temperature 103.4°; pulse 116. Two chills. May 29, a.m., temperature 101°; pulse 108: p.m., temperature 99.4°; pulse 72. Slight hæmorrhage and some odor. May 30, a.m., temperature 98.4°; pulse 72: p.m., temperature 100°; pulse 84. May 31, a.m., temperature 99°; pulse 68: p.m., temperature 99.6°; pulse 96. Slight hæmorrhage and some odor. June 1, a.m., temperature 98.2°; pulse 88: p.m., temperature 99°; pulse 72. June 2, a.m., temperature 97.8°; pulse 70: p.m., temperature 99°; pulse 84. Slight hæmorrhage. June 3, a.m., temperature 98.2°; pulse 84: p. m., temperature 99.2°; pulse 100. Severe hæmorrhage. Vagina is packed. June 4, a.m., temperature 98.2°; pulse 80: p.m., temperature 99.4°; pulse 88. Packing is removed. No hæmorrhage. June 5, hæmorrhage leads to curettement. P.m. temperature 99.4°; pulse 88. Normal puerperium. (See Chart 4.)

Under expectant treatment the temperature which had been as high as 103.4°, accompanied by chills came down to normal, the foul odor of the vaginal discharge disappeared and, when ultimately a more severe hæmorrhage required packing and curettement, no further rise of temperature occurred.

In addition to this case, four others were of the same type.

CASE 8. Pregnant 2 months. Patient had introduced slippery elm into her uterus 2 weeks ago, had had chills and fever for 4 days, had a purulent

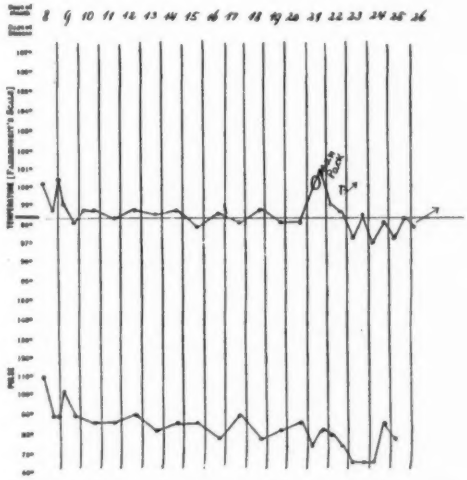

Chart 7, Case 9, *O*, operation; *Man.*, manual removal; *P*, packing removed; →, patient discharged.

discharge from the vagina and a temperature on admission (June 21) of 103°, pulse 150. June 22, a.m., temperature 102.2°; pulse 146: p.m., temperature 102.6°; pulse 118. June 23, a.m., temperature 99.4°; pulse 100: p.m., temperature 101.6°; pulse 100. June 24, a.m., temperature 98.8°; pulse 88: p.m., temperature 100.2°; pulse 88. June 25, a.m., temperature 98.6°; pulse 100: p.m., temperature 99°; pulse 76. Fœatus is expelled spontaneously. June 26, a.m., temperature 98.2°; pulse 84. Manual removal of placenta on account of hæmorrhage. Uterus packed. Immediately thereafter chill, temperature 103.2°; pulse 112. June 27, a.m., temperature 98.2°; pulse 78: p.m., temperature 99.4°; pulse 88. Packing removed. Normal puerperium. (See Chart 5.)

CASE 9. Pregnant 4 months. Hæmorrhage 3 days before admission on April 8th with temperature of 100.8°; pulse 108. 2 a.m., chill temperature 101°; pulse 88. April 9, a.m., temperature 99.8°; pulse 100: p.m., temperature 98.8°; pulse 88. April 10, the fœtus is passed spontaneously. Temperature 99.4°; pulse, 84.

The temperature continued normal until on April 21, on account of hæmorrhage which had persisted, manual removal of placenta and packing of the uterus was performed. In the evening, temperature 101.4°; pulse 84. April 22, the packing is removed, then temperature remains normal and a normal puerperium follows. (See Chart 7.)

Under expectant treatment, in these two and three other similar cases, the temperature which had been as high as 103° accompanied by chills, in one case following criminal interference with pregnancy, dropped to normal and, when operative interference became necessary, it was followed by a single rise of temperature (in one case with chill) and afterward by normal temperature and normal puerperium.

In 5 cases it became necessary to operate while the temperature had not yet returned to normal. None of these cases, however, suffered any damage from the operative interference and in all the temperature was normal on the next day and all had normal puerperium.

Case 10 (see Chart 6) is an example of this type.

CASE 10. Patient pregnant 4 months. Hæmorrhage 4 days. Two chills the day before admission on May 11, with temperature of 103.2°; pulse 106. One chill was observed on the day of admission to the hospital.

May 12, a.m., temperature 102°; pulse 112: p.m., temperature 107°; pulse 136. Two chills, hæmorrhage. May 13, a.m., temperature 103.4°; pulse 100. Severe hæmorrhage necessitates manual emptying of uterus and insertion of packing. P.m., temperature 99°; pulse 100. Perfectly normal recovery.

It is evident from the described cases that the expectant treatment has in no case led to undesirable results in the puerperium, which is a great deal more than can be said for the active treatment of septic abortion. In years gone by, it has been by no means rare in the author's experience as well as in that of others to see cases of septic abortion treated actively and followed by rapid septic symptoms and not at all unfrequently by fatal results. We have had no deaths and not one case of puerperal sepsis in this series.

Out of the 21 cases of septic abortion described, only 7 had any rise of temperature after the completion of the abortion, five a single rise and two for two days, both of the latter and three of the others having been packed and the temperature disappearing on removal of the packing.

Packed cases may as a general rule be expected to show a slight rise of temperature in comparison with cases not packed.

While after spontaneous abortion the average temperature was 98.8°, there was in cases which had any rise of temperature after abortion, the following average temperature after the various operative procedures:

	Average Temperature	Number of Cases
Manual emptying of uterus	100.3	5
Curettement of uterus	100.6	8
Manual emptying and packing of uterus	100.8	9
Curettement and packing of uterus	101.5	3
Combined manual emptying, curettement and packing of uterus	102.5	3

These cases are figured irrespective of presence or absence of fever previous to the completion of the abortion.

Though the series is small, a slight increase in the temperature in packed cases in comparison with cases not packed is fairly evident. Also it is evident that with the increasing severity of manipulation, an increase in the temperature reaction goes hand in hand. If we simply count all packed cases

irrespective of other conditions, we find in 156 cases, 23 which had been packed, with an average temperature after the abortion of 100.4°, the highest (103.6°) occurring only once.

In the entire 156 cases of abortions 28 or 18 per cent had temperature over 100 after the abortion, while the character of the septic abortion finds expression in a higher proportion of cases with fever after the abortion. This proportion in cases of septic abortion is 7 out of 21 or 33 per cent. In 98 cases which had not reached 99° before or during the abortion, there were only 3 or 3 per cent which had 100° or slightly over after the abortion.

CONCLUSIONS

From this experience we may, therefore, draw the following conclusions:

Cases of abortion without fever may safely be left to spontaneous termination, the only contra-indication being severe or protracted slight hæmorrhage.

Cases of septic abortion are no exception to this rule. They can terminate spontaneously according to Type 1 (Charts 1 and 2), in which the abortion takes place spontaneously during the fever and the fever drops after the abortion; or according to Type 2 (Chart 3), in which the fever drops under expectant treatment and the abortion takes place subsequent to the fall of the temperature.

In cases of septic abortion, the temperature may be expected to drop under expectant treatment and, if interference becomes necessary, Type 3 (Chart 4) of the temperature curve may be observed, no rise of temperature after the operation; or, Type 4 (Charts 5 and 6), a short rise of temperature after the interference followed by rapid and final fall of temperature.

Lastly severe hæmorrhage necessitating evacuation of the uterus in the presence of sepsis may be followed by immediate and lasting fall of temperature (Chart 7).

The foundations for my conceptions of the pathology of septic abortion are the same as outlined in the above quoted paper on the treatment of puerperal infection of the uterus and do not require repetition.

The treatment which we recommend and carry out in cases of septic abortion is as follows:

If a patient with septic abortion is admitted to the hospital, expectant treatment is followed until the abortion is completed spontaneously. Rectal examination is used exclusively and that as rarely as possible. The patient is kept in bed and on a light diet. If severe or protracted slight hæmorrhage makes interference unavoidable, the uterus is packed. The packing is removed after 12 to 24 hours and frequently the whole remnants of the abortion come away with the packing. If not, the packing has usually dilated the cervix sufficiently so that the uterus can be emptied manually. Repeated packing is not favored as dangerous in itself. If the uterus is not empty after the removal of the packing, it is emptied preferably by hand, if necessary after additional dilatation with Hegar's dilators and if the hand is insufficient, with the sharp curette. The longer the interval between the last rise of temperature and the operation the better. Packing afterward is avoided, unless necessitated by severe hæmorrhage. The uterus is never irrigated. Ergot is given only when hæmorrhage exists after complete evacuation of the uterus. Vaginal douches are never given until at least a week after the abortion and then only for subinvolution, not for purulent discharges. If the temperature is normal after the abortion, the patient is allowed out of bed at any time she feels ready, unless she is very anæmic. The patient is fed well as soon as possible. The patient is discharged three days after the last rise of temperature, unless anæmia, subinvolution, etc., require longer hospital treatment. Rectal examination is repeated before discharge.

THE METHOD OF NEW JOINT FORMATION IN ARTHROPLASTY

An Experimental Study[1]

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THE attempts at re-establishment of mobility in ankylosed joints had their origin in observations of two types.

The first was that joints with marked temporary reduction in mobility from injury or disease gradually improve with the subsidence of the exciting factor. Passive motion has always been used in such cases to hasten the return of function, and especially since the introduction of anæsthesia the procedure has been widely extended to the forcible breaking up of adhesions — *brisement forcé* — with the re-establishment of as much mobility as possible, to be followed by active and passive motion in the hope of maintaining most of the advantage thereby gained.

The second observation was in connection with the end-results of resected joints. When a limb was ankylosed in an undesirable position, as the elbow with the arm extended, resection was sometimes practiced and the limb flexed for the purpose of obtaining an ankylosis in a more useful position. Not infrequently such resections were followed, not by ankylosis, but by the re-establishment of considerable mobility in the joint. A similar result sometimes but less often followed resection for the removal of active disease, as tuberculosis and infected gunshot wounds of the joints. Thus Textor reported an ankylosis of the elbow operated on at the age of 51 where, 6 years later at the time of death, there was full range of motion. Fergusson presented before the Royal Society of London in 1861 a 20 year old girl who had almost complete mobility and weight-bearing capacity in the limb 5 years after resection of the knee-joint, for tuberculosis. It was also observed by Doutrelepont, Czerny and others at postmortem examination of such resections years afterward that an atypical new joint cavity forms with a synovial lining and in some instances articular cartilage covers the ends of the bones.

These results awakened a lively interest and led to much dispute as to which method of performing resection was followed by the greatest amount of mobility. Ollier and Langenbeck[2] made subperiosteal resections in the expectation that the resected portions would be partly regenerated and thereby give a better joint. Defontaine performed a curvilinear resection of the elbow in order to better preserve the contour of the joint surfaces. The amount of bone removed was varied greatly and in general it was noted that while the range of mobility was widest in extensive resections, the joint was more apt to be flail and of little use.

After many trials there was still much uncertainty as to the advisability of attempting resection for the sole purpose of obtaining mobility. At the beginning of the nineties, Ollier was about the only one who wrote in favor of it, Hoffa, Lossen, and Koenig advising against interference even in case of the elbow when the ankylosis was at a desirable angle.

Such was the situation when Julius Wolff made his first report on operation for ankylosis of the elbow in 1895. He modified the procedure to what he termed arthrolysis which consisted in cutting through the bony or fibrous ankylosis in the line of the joint without resecting the ends of the bones. His first operation was performed in 1887 for fibrous ankylosis with a brilliant result and, following this, good range of mobility was also obtained in cases of bony ankyloses.

In an endeavor to lessen still further the possibility of a recurrence of ankylosis, Helferich in 1893 began the interposition of a flap of muscle between the ends of the bones. He was led to the attempt by the observation that, in operations on ununited fractures, muscle interposed between the ends of the fragments was a rather common finding. His

[2] Langenbeck. See Lossen.

[1] Presented before the Chicago Surgical Society, March 2, 1917. (See discussion page 474.)

first operation was for a recurrent ankylosis of the jaw following a previous resection of the joint. After removal of the condyle of the mandible a pedunculated flap of the temporal muscle was turned downward and sutured into the joint space. The functional result was excellent. This plan of operation was quickly extended to the other joints of the body by Rochet, Hoffa, Nélaton, Quénu, Delbet, Schantz, Albarran, and others. Murphy advocated the use of pedunculated flaps consisting of fascia and fat, and subsequently put this method into most extensive clinical use.

The majority of surgeons employing the pedunculated flap claimed that in some way it participated in the formation of the new joint but there was no uniformity as to the exact method in which this was accomplished. Others claimed that the flap broke down and rapidly disappeared, and consequently they began using more durable or non-absorbable foreign materials with the idea of keeping the bony ends separated during the formation of the joint surfaces.

The attempts with non-absorbable materials such as zinc and silver foil, rubber and celluloid were soon abandoned but the slowly absorbable, prepared animal membranes have been tried out more extensively. Thus Baer interposed chromicized pig's bladder which required from 30 to 40 days for absorption. Cargyle membrane and amnionic membrane have been used to some extent.

The objection to the chemically fixed membranes has been made that they produce too much tissue reaction. In an endeavor to avoid this and at the same time prolong the durability of the interposed substance, Allison and Brooks have used fascia impregnated with non-irritating metallic silver.

Since the establishment of the feasibility of tissue transplantations, free flaps of fat and fascia, and of muscle and fascia have been employed, particularly in joints about which it is difficult or impossible to secure a suitable pedunculated flap. Kirschner and MacAusland were among the first to advocate this method, although Murphy used it on the knee-joint in 2 cases 10 years before but abandoned it for the pedunculated flap.

When the manner in which the new joint forms is approached, we find almost as many views expressed as there are methods of performing the operation. It was for the purpose of attempting to clear up this point that the following experimental work was done. Three types of operations were performed (*no flap, pedunculated flap, and free flap*) and the results of each were studied and compared. The theories advanced as to the method of joint formation in each type of operation are given as an introduction to each set of experiments.

There are a number of factors which exert such a modifying influence upon the process of joint formation that they are reviewed in advance of the experiments.

1. *The type of joint operated on.* Experiments were performed on the knee and on the elbow. Since both are weight-bearing joints in the dog, there is not the difference from static influence which exists in the case of man. However, the actual difference in this respect is not very great, as in neither instance does the animal use the limb operated on for a number of weeks, and the pressure effects result very largely from the tension of the soft parts. In general, better results were obtained on the elbows both as to range of mobility and weight bearing. This is because the elbow is a more perfect hinge joint than the knee, and particularly because in it a better fitting and more stable joint can be reconstructed after resection.

2. *The condition of wound healing.* This is of great importance. Attention should be called to the great frequency of infection which is attributed to the extensive and mutilating nature of the operations. Out of 89 operations, 39 were infected in varying degrees, and many to such an extent that they either resulted in death of the animal or were discarded as useless for the study. Gloves were used, the skin walled off, and the amount of hand contact reduced to a minimum. Superficial infection sometimes occurred without apparent involvement of or influence upon the evolution of the joint. In other instances of outwardly clean operations, evidence of deep-seated mild infection was detected upon gross or microscopic examination.

In general, infection decreased the range of mobility obtained, but its presence by no means signified the development of ankylosis, as in a few instances fair mobility was obtained despite the existence of a purulent discharge during the first few days. There was more thickening about the joint in the infected cases and consequently a greater tendency for stiffness to progress as time went on. In no instance did a sinus persist after the third week nor extensive infection of the bone with sequestration occur.

3. *Variation in the amount of tissue removed.* The technique of the operations was as follows:

1. On the elbow the lateral incision of Kocher was used. In the flap operations a suitable layer of the deep fascia was dissected downward with its pedicle over the head of the radius, and the joint opened from the side by detaching the structures attached to the external condyle and incising the lateral portion of the capsule without detaching the triceps from the olecranon except in the first six operations, which variation seemed to make no difference in the result. The amount of tissue removed from the ends of the bones varied from the articular cartilage and most of the underlying cortical bone in the earlier experiments to rather extensive curvilinear resections of the ends of the bones in some of the later ones. The intercondylar groove of the humerus and the opposing ulnar ridge of the olecranon fossa were preserved in all cases so that even in the extensive resections the joint contour and stability were well preserved. After completion of the joint operation, the muscles were reattached and the capsule sutured wherever possible.

2. At the knee-joint a curved incision with its convexity downward was made across the front and extended upward on the lateral surface of the lower third of the thigh in case a free or pedunculated flap was interposed between the ends of the bones. The joint was then opened by free incisions internally, externally, and along the lateral margin of the tibiopatellar tendon and patella. The patella and tendon were then displaced mesially. In the earlier experiment the tibiopatellar tendon was cut. the semilunar cartilage and crucial and alar ligaments were excised and the ends of the tibia and femur exposed. As a routine, the articular cartilage and underlying bone were removed with a chisel in the earlier cases, and a saw in the later ones, after which the ends of the bones were reshaped with a gouge, the condyles being rounded off, the intercondylar groove deepened and the tuberosities of the tibia leveled off leaving an intervening median ridge running anteroposteriorly and fitting into the intercondylar groove. The articular cartilage of the patella was usually removed with a chisel. In the experiments where it was not removed, mention is made of the fact.

In some of the experiments the resection was slight while in others it was extensive. In general the less the resection the greater the stability of the joint. With the more extensive resections the mobility was usually good but the joint was inclined to be flail and useless. The less the resection the greater the flap necrosis. Also the less the resection in well shaped and used joints, the greater the cortical sclerosis of the articular surfaces. These points will be fully dealt with later on.

The capsule was always sutured where possible but in the cases where a flap was cut from the side, practically no lateral capsule was left, in which event the greater portion of the defect was left open. Complete excision of the synovial membrane and ligaments of the joint was not made in any of the experiments. In joints ankylosed by inflammation, these structures are found thickened, adherent, and contracted, and the necessity for their excision in order to prevent rapid recurrence of adhesions has been pointed out especially by Murphy and Payr. Capsule excision was practiced in all of the experiments of Sumita. The necessity of this step does not seem obvious as in these animals the remaining portions are normal, and should facilitate rather than impede the re-formation of a satisfactory joint.

4. *Variation in the amount of function.* This includes weight bearing and motion in both joints, and is one of the most difficult factors to control, differing widely from our experiences in man where we usually have the intelligent co-operation of the patient.

A silicate of soda bandage was applied at

operation and left on from 4 to 8 days depending on the behavior of the wound. As a rule all dressings were left off by the eighth or ninth day. The animals were allowed to run loose and no passive motion or manipulation was carried out on the joints. Usually little attempt was made to use the joint even in the most favorable cases before a number of weeks had elapsed. In some instances immobilization of the joint was prolonged either intentionally or because of the condition of the wound, and it was observed that the longer the immobilization was continued the less the range of motion established. Prolonged immobilization leads to ankylosis, although union is much slower about developing than in the case of an ordinary fracture.

5. *The variation with displacements.* A varying amount of displacement was a common occurrence, especially in the knee-joint and when the resection was extensive. The tibia was frequently displaced backward so that the condyles rode over the tibiopatellar tendon. Lateral displacement and some rotation were also met with and the patella was occasionally found displaced inward. All displacements were detrimental to the restoration of proper function and the greater the degree the more marked the disturbance.

6. *Variation in the substance interposed.* This is of such importance that the 54 experiments studied will be analyzed according to the types of joint spaces that were produced. In the first set of experiments, nothing was inserted into the joint space — (no flap operations); in the second set we used a pedunculated flap of fascia frequently containing a certain amount of muscle, and in the third set a free flap of the same material.

NO FLAP OPERATIONS

Twenty experiments were studied, 17 of which ranging in age from 8 to 128 days were clean and 3 were infected. Six were on the elbow, all of which were clean and 14 on the knee-joint.

The changes which take place in resections in man followed by movable joints are of the greatest interest here. As previously stated examination at autopsy of such resected, movable joints years afterward showed an imperfect joint with a cavity and bony articular surface covered by fibrous tissue or by newly-formed articular cartilage. No one attempted to give a detailed account either from clinical or experimental studies of the changes through which the various portions of the joint go in the process of new joint formation until the work of Hohmeier and Magnus. They performed nine "no flap" operations on the knee-joints of rabbits and in every case obtained stable joints with complete restoration of mobility.

The small amount of experimental work and scarcity of information as to what happens in this type of operation as contrasted with the arthroplasties with interposed substances is to be explained by the fact that since the introduction of the latter procedure the opinion has crept in and has gradually become accepted that a stiff joint almost invariably forms unless some substance is interposed. For this reason the results in this series were noted with particular interest.

NO FLAP EXPERIMENTS

8-day experiment. Dog No. 3. Elbow-joint. Articular cartilage and small amount of cortical bone removed with chisel. Dressed third day. External wound clean. Eighth day died.

Necropsy. Skin closed but incision in capsule open — catgut sutures loosened. No clotted blood in joint cavity. Capsule thickened and apparently inflamed. Articular surfaces smooth and partly covered by a thin layer of either fibrinous exudate or granulations from the ends of the bone. Prominent portions of condyles and ulnar crest bare and slightly polished.

Microscopic examination. Humerus. Transverse section through lateral condyle of humerus shows fairly smooth articular surface. There is a thin layer of necrotic bone along most of its extent which is separated from the underlying living bone by a layer of granulation tissue in which region the bony trabeculæ are largely destroyed. The immediate underlying living bone has a fibrous marrow with a small amount of newly formed bone and the deeper marrow is hyperæmic (Fig. 1).

Ulna. Anteroposterior section along ulnar ridge shows smooth surface of bare bone in most of its extent but with thin covering of granulation tissue over one area. Marrow along surface slightly fibrous. No newly formed bony trabeculæ as yet.

The joint showed evidences of mild infection in the breaking open of the sutured incision in the capsule and the sequestration of

the necrotic layer by the action of granulation tissue along the surface of the condyle. Aseptic necrotic bone along the surface as seen in other specimens does not become separated as a sequestrum. There was as yet little cortical new bone formation in the fibrous marrow.

11-day experiment. Dog No. 34. Knee-joint. Tibiopatellar tendon cut. Articular cartilage and small amount of underlying bone removed from all three bones with chisel. No flap used. Dressed third day; clean. Died eleventh day.

Necropsy. Tibiopatellar tendon united by slender fibrous band. Capsule open anteriorly on either side of tendon. Closed on sides. Patella adherent to femur, but movable. Anterior recessus of joint obliterated. Joint space between femur and tibia.

Tibia. Intertubercular ridge has a dense, bare, shining surface. At site of insertion of anterior crucial ligament there is a fibrous covering. Surfaces of tuberosities uneven; all cortical bone removed; central portions of the tuberosities are bare; peripherally they have irregular fibrinous covering.

Femur. The prominent portions of the condyles are bare and smooth, but at the sides especially in front and behind where there is no pressure there are areas covered by fibrous tissue.

Microscopic examination.. Section anteroposteriorally through intercondylar groove near mesial condyle shows a fairly thick covering over the fairly regular bony surface, which consists of fibroblasts except along joint surface where there is a thin fibrinous covering which is being replaced by the outgrowing fibrous tissue. A narrow strip of cortical bone had been removed along most of the surface leaving the marrow spaces open. The superficial marrow has become fibrous. Along posterior margin there is an overgrowth of fibrous tissue from the sides. Anteriorly an unusual condition is found. There is considerable ossification of the fibrous covering of the articular surface, without any new bone formation in the fibrous marrow of the underlying bone. The newly formed trabeculæ radiate from the bony surface and in places extend almost to the surface of the fibrous covering. The fibrinous layer is absent in this region and the fibrous layer is thicker than it is along the posterior half and the extreme anterior margin.

The covering of soft parts is in keeping with the fact that the intercondylar region is less subject to pressure and that a fibrous outgrowth can occur. But the ossffication in much of its anterior portion is exceptional. There was a prominent crest opposite it on the tibia and the tuberosities appeared to be considerably eroded from the pressure of the condyles. Perhaps this erosion brought the tibial crest into contact with the intercondylar groove after a fibrinous and fibrous layer had formed and the ossification then began in the layer in response to the stimulus.

12-day experiment. Dog No. 9. Elbow. Articular cartilage and most of the underlying bone cortex was removed with a chisel. No flap used. Dressings removed eighth day. Wound clean. Twelfth day dog died.

Necropsy. Incision in capsule healed. Some limitation of motion in joint. Capsule somewhat thickened; small amount of synovial fluid present. Bony surfaces where subject to pressure, bare and shining, but about margins and in recesses where there is little pressure there is an irregular fibrinous covering. Small area over anterior trochlear surface of ulna with a cartilaginous covering, the articular cartilage not being removed.

Microscopic examination. Anteroposterior section through lateral condyle shows smooth surface consisting of bare bone along most of the prominent portion of the condyle. Little cortical bone was removed in this region. In one place near the crest of the condyle, there is a small island of unremoved cartilage which is being overgrown from the sides by fibroblasts. The surface along the middle portion of the condyle consists of bare, smooth bone with a small amount of necrosis in the superficial trabeculæ, superficial necrosis, fibrous marrow, and here and there new bone formation in the cortical cancellous spaces. About the margins anteriorly and especially posteriorly where there is less pressure there is a surface covering which is fibrinous in its outer portion but consists in its deeper portion of fibroblasts growing out from the cancellous spaces of the bone and over from the sides. Cortical marrow, fibrous, but with no new bone formation.

Much of the cortical bone had not been removed. The areas subjected to pressure were bare and showed beginning cortical new bone formation. About margins there was a fibrinofibrous covering with superficial fibrous marrow and no new bone formation.

14-day experiment. Dog No. 73. Knee-joint Articular surface of patella not removed. Fairly extensive removal of surfaces of femur and tibia. Seventh day bandage removed. Wound clean. Fourteenth day killed. Limb not used.

Necropsy. There was fifty degrees of motion in joint. Some lateral mobility. Capsule thickened, patella mobile. Incisions in capsule healed. Patella and tibiopatellar tendon adherent to anterior femoral surface by loose fibrinofibrous adhesions. There is a joint cavity between the femur and tibia

with few adhesions extending across it in intercondylar portions. Bony surfaces of internal condyle and intercondylar groove and tuberosity of tibia bare, smooth and slightly eburnated where in contact. There is a loose covering of the articular surfaces about the margins and in the region of the external condyle and tuberosity where there was little or no pressure.

Microscopic examination. Transverse section through prominent portion of condyles of *femur.* The internal condyle and most of the intercondylar groove have a bare, smooth, bony surface with necrosis of the tips of the bordering trabeculæ. Small particles of the eroded bone dust are seen ground into the open ends of the marrow spaces. The superficial marrow is fibrous and there is some cortical new bone formation in the medullary spaces (Fig. 2).

The external condyle which was subjected to little pressure has a fairly thick covering which consists of a fibrinous layer along the surface and of a newly formed fibrous layer in its deeper portion. The cortical bone is spongy; its marrow is fibrous and the fibrous covering has grown out from the marrow spaces and is invading and replacing the overlying fibrinous layer. There is no cortical new bone formation (Fig. 3).

The *tibial* surface shows the same changes. The internal tuberosity and crest where in contact with femur are bare and show cortical new bone formation, while the external tuberosity has a covering similar to that of the external condyle (Fig. 4).

This experiment illustrates well the early changes in joint formation. As a result of motion a joint space forms between tibia and femur. Where opposing bones are in contact and subjected to pressure the surfaces are bare and becoming sclerotic. Where loosely in contact and free from pressure they have an outer fibrinous and inner fibrous covering, the latter growing out from the superficial fibrous marrow and gradually replacing the fibrinous layer, with no cortical new bone formation.

17-day experiment. Dog No. 11. Young dog. Elbow. Considerable bone removed from humerus and ulna. Bandage removed on thirteenth day. Wound clean. Fair joint mobility. Died seventeenth day.

Necropsy. Capsule healed. On opening joint large cavity is present which contains organizing blood-clots. The intercondylar groove of the humerus is very deep and broad, and has an irregular, raw surface. The condyles are narrow and bare along their prominent portions. The capsule is adherent along the sides obliterating the lateral recesses of the joint. The ulnar surface is almost entirely covered by a layer of fibrin and fibrous tissue. The radial head is covered at the periphery by a fibrous overgrowth. The central portion has a cartilaginous covering.

Microscopic examination. A transverse section through the middle shows the surface of the prominent portions of the condyles bare with little of the normal cortical bone removed. In their superficial marrow spaces there is a small amount of new bone formation. At the sides of the condyles the capsule is adherent and osteophites are beginning to form. Intercondylar groove has irregular spongy bony surface largely covered by a thin fibrous outgrowth from the open marrow spaces. In places bands project from the surface which represent divided adhesions that were in process of formation. No smooth fibrous and fibrinous covering seen in most of extent of joint surface.

Ulna. Articular surface has fibrous covering over almost entire extent. Superficial marrow spaces contain a small amount of fibrous marrow and new bone. Osteophites are found at sides and slight periosteal new bone formation on dorsum of olecranon opposite the joint.

Radial head shows joint surface about sides largely obliterated and a fibrous covering of periphery which has grown out from the bony surface. The island of cartilage at the center of end is overgrown at sides by fibroblasts.

18-day experiment. Dog No. 84. Knee. Extensive removal of ends of tibia and femur and cartilage from patella. Bandage removed eleventh day; clean. Killed eighteenth day.

Necropsy. Joint mobility considerably limited with limb in extension. Capsule firmly united. Anterior and upper recessus obliterated by adhesions between patella, tibiopatellar tendon and femur. On cutting capsule at sides a small joint cavity is entered between tibia and femoral condyles. Their surfaces are bare at points of contact but have thin reddish covering about margins anteriorly and posteriorly.

Microscopic examination. Femur. The surface beneath patella has a fibrous covering. There is irregular ossification beginning to extend out into covering from the underlying spongy cortex which has slight cortical fibrous marrow.

Transverse section through the prominent portions of condyles shows a thick fibrous capsule at either side with condylar surfaces largely covered by thin, irregular fibrous and fibrinous layer without any cortical sclerosis. The intercondylar region is only slightly depressed with the old cortical layer of bone present. Its articular surface is bare and polished and there is some underlying cortical new bone formation. It was largely the weight-bearing portion of the joint coming in contact with the opposing tibial crest.

Tibia. Very extensively resected. The section transversely through the upper end shows epiphysis removed beneath the epiphyseal line laterally and

to just above the line mesially. Tibial crest prominent with bare, slight sclerotic surface. Tibial tuberosities have fibrous covering running irregularly parallel to surface. Their bony surfaces are spongy and show no new bone formation.

The tibial crest and intercondylar groove being in apposition kept the more extensively resected condyles and tuberosities apart, consequently the former were the weight-bearing portions and acquired a bare sclerotic surface while the latter became covered by a fibrous outgrowth from the marrow spaces.

19-day experiment. Dog No. 10. Elbow. Articular cartilage and some cortical bone removed with a chisel. Dressing removed eighth day. Wound clean. Dog died nineteenth day.

Necropsy. Incision in capsule healed. Joint opened. Fair sized cavity; lateral recessus, obliterated in places by adhesions of capsule to sides of bone ends. Some fibrinous flakes in joint cavity. No signs of active inflammation. The articular surface of the *humerus* shows prominent portion of either condyle bare and dense, but anteriorly and posteriorly they are somewhat grooved and irregularly depressed with a covering of fibrous tissue.

Ulnar surface is largely bare, especially along the crest and trochlear surface. Laterally the articular surface is depressed and covered by a reddish layer of granulations which seem to be eating in on the side of the ulnar crest. Radial joint obliterated largely about the sides. The end of the radius is bare and dense except in the depressed central portion where there is small fibrous covering.

Microscopic section through the external condyle of *humerus*, anteroposteriorly. The bare prominent portion consists largely of dense old cortical bone with a small amount of new bony trabeculæ. The depressed grooved surfaces have spongy, bony walls with a fibrous covering and no new bone formation. This fibrous covering seems to be growing onto and absorbing and replacing the dense bare prominent portions.

This is an instance of the grooving and extensive absorption of the bony surfaces that were not pressed upon while the bare weight-bearing portions persisted and showed evidences of sclerosis. The extensive absorption may have been the result of mild infection but other definite evidence of it were not still present upon microscopic examination.

51-day experiment. Dog No. 54. Knee-joint. Moderate resection. Immobilized the entire time. Animal killed.

Necropsy. Very slight mobility. Patella fixed to femur. No special thickening about joint. Longitudinal section through femur, patella, and tibia shows complete obliteration of joint cavity. Patella extends down to joint between femur and tibia. There is ankylosis between tibia, femur, and the patella by a broad fibrous band which is cartilaginous along the bony surfaces anteriorly. The ankylosis between patella and femur is by a narrow band which is fibrous in its upper portion and cartilaginous at its junction with the broad band between tibia and femur. Epiphyseal lines open (Fig. 11).

Microscopic examination. No joint cavity present. There is a broad fibrous ankylosis between tibia and femur averaging 6 cubic centimeters in thickness. There is an ankylosis between patella and femur, the lower end of the patella extending down to the lower end of the femur. The bridge of tissue between patella and femur is fibrous and broad in its upper portion where slight ossification is proceeding from its walls, and narrow and cartilaginous in the lower portion where enchondral ossification is proceeding rapidly from both sides. The bridge between tibia and femur is fibrous in its posterior two-thirds where ossification is proceeding slowly, from the spongy bony surfaces largely by fibrous new bone formation. The anterior third is filled by a tissue which is fibrous in its middle portion but cartilaginous along the bony surfaces where it is undergoing ossification by extensive enchondral new bone formation.

The joint in this experiment was treated as in a resection or as a fracture and shows the effect of prolonged immobilization. A fibrous ankylosis occurred with complete obliteration of joint cavity, and ossification of the fibrous bridges is proceeding from the bony surfaces partly by fibrous, partly by enchondral bone formation.

There is a striking difference between the ends of the bones in this ankylosed, resected joint and the ends of the bones in a healing fracture of the shaft showing that the anatomical changes in the two processes are by no means analogous.

55-day experiment. Dog No. 52. Knee-joint. Moderate curvilinear resection. Tibiopatellar tendon cut and sutured. Wound became moderately infected. Wound dressed for 15 days. Range of motion about 45 degrees.

Necropsy. The capsule has entirely regenerated. The patella is firmly adherent by an osseous fibrous union to the femur. The tibiopatellar tendon is thin. There is a moderate sized joint cavity over either condylar region, the limb being held in slight flexion. Between the two compartments there is a loose fibrous partition. The femoral condyles are largely bare, dense, and shiny, especially over the external one; elsewhere they have a fibrous covering. The mesial tuberosity and crest of the tibia are covered by fibrous tissue, most of the surface of the

external tuberosity which opposed the bare femoral condyle being bare and dense.

Microscopic examination. Transverse section through tibia. There is marked thickening of the capsule at either side of the joint and ossification by metaplasia into cartilage and bone proceeding from the sides of the end of the bone. The articular surface is irregular, with a prominence in the region of the tibial spines. The surfaces opposite the femoral condyles are covered by an irregular layer of fibrous tissue except over the outer half of the lateral tuberosity where the bony surface is dense and bare (opposite a similar area on the external condyle). The mesial portion of the external tuberosity and the mesial tuberosity are slightly depressed and have a bony surface with slightly increased trabeculæ, showing a small degree of absorption of the trabecular ends and new bone formation. The fibrous covering presents a broad cut surface to either side of the tibial spine, representing the cut ends of adhesions to the femur (joint septum). The surface of the joint cavity on either side is extremely irregular and necrotic in most of its extent. Mesially there are villi and pockets. There is little tendency to ossification of the fibrous covering of the joint cavities. The fibers have an irregular radiating arrangement.

Transverse section through femoral condyles. The same thickening of the capsule and ossification from the sides of the ends of the bone are seen. The condylar bony surfaces are extremely irregular. There are two deep, broad grooves in the external condyle separated by a broad, dense, bare, sclerotic, bony surface. The walls of these grooves are of spongy bone and show surface absorption. The fibrous tissue filling them is mature in its deeper portions and necrotic along the surface. An adhesion from the mesial groove presents a cut surface. The floor of the intercondylar space consists of radiating fibrous tissue, and the sides are of dense, bare bone which is newly formed on the lateral wall. The mesial condyle is irregularly depressed by absorption of the bony trabeculæ. The bony surface is spongy and there is evidence of absorption and a little new bone formation. The fibrous covering is thick and dense in the deeper portion, and necrotic along the surface except about the middle where there is a suggestion of differentiation into a cartilaginous layer.

The marked grooving, surface absorption and thickening and ossification of the capsule which are the result of the infection favor the occurrence of ankylosis, but despite these the ends of the bones show an endeavor at new joint formation.

56-day experiment. Dog No. 33. Knee-joint. Tibiopatellar tendon cut. Cartilage and some of underlying bone removed with chisel. Bandage removed on fourth day. Superficial infection. Healed in 2½ weeks. Killed after 56 days.

Necropsy. Animal did not use the joint. Range of motion 90 degrees. Limb held in moderate flexion, extension limited, capsule very thick. Patella retracted upward as result of giving away of tibiopatellar tendon and fixed to femur. Anterior recessus of joint obliterated. On cutting between tibia and femur a small joint cavity found between condyles of femur and tibial surface. Synovial fluid present. External condyle in region of joint partly bare and polished, partly covered by necrotic fibrous layer. Internal condyle and intercondylar groove and upper end of tibia completely covered by fibrous layer. There are no adhesions bridging joint cavity but there has been an ingrowth from the capsule between ends of bones, decreasing the size of joint cavity.

Microscopic examination. Tibia. Transverse section through articular surface of tibia shows a fibrous covering over its entire extent. Bony surface is depressed and spongy over lateral tuberosity and covered by fibrous tissue which runs parallel to surface resembling an adherent flap (Fig. 5). The fibers of the covering of the internal tuberosity run irregularly. Tibial crest is low and rounded off. No new bone formation along articular surface.

In this mildly infected joint there was giving away of the sutured tibiopatellar tendon, obliteration of the anterior recessus, and small joint cavity formation between tibia and femur. The restriction of motion was produced by the gradual obliteration of the joint cavity by fibrous ingrowth from the periphery. The articular surfaces were overgrown by a fibrous covering except a portion of the external condyle, showing the tendency for this to occur where there is infection, with little motion and use of the joint. The fibrous covering runs parallel to the bony surface in some places and could easily be mistaken for surviving flap in case one had been interposed.

55-day experiment. Dog No. 52. Knee. Resection with saw and chisel. No flap used. Wound slightly infected. Daily dressings until the eighteenth day when the wound was healed. Dog killed on fifty-fifth day. Range of motion 50 degrees.

Necropsy. Capsule completely regenerated. Patella firmly adherent by ossifying fibrous tissue to the femur. Tibiopatellar tendon thin. Moderate sized joint cavity over either condylar region, the limb being in slight flexion. There is a fibrous partition anteroposteriorly between the cavities. The bony surfaces of the *femur* are largely bare, dense, and shiny, partly covered by fibrous tissue. The mesial tuberosity and crest of the *tibia* have a fibrous covering, the external tuberosity being bare and dense.

Microscopic examination. Tibia. Transverse section. Marked thickening of the capsule at either side of the joint with ossification by metaplasia into cartilage and bone proceeding from the sides of the bone ends. Bony surfaces irregular with a prominence in the region of the tibial spine. Condylar surfaces covered by an irregular layer of fibrous tissue except over the outer half of the lateral tuberosity where the bony surface is dense and bare (opposite a similar area on the external condyle of femur). The mesial portion of the external tuberosity and the mesial tuberosity are slightly depressed and have a bony surface showing a small amount of absorption of the trabecular ends and new bone formation. The fibrous covering shows a broad cut surface at either side of the tibial spine, representing the cut ends of an adhesion to the femur. (Joint septum). The surface of the joint cavity on either side is extremely irregular and necrotic in most of its extent. Mesially there are villi and pockets. Little tendency to ossification of the fibrous covering which has a radiating arrangement.

Femur. Transverse section. Some thickening of the capsule and ossification from the sides of the bone ends. Condylar bony surfaces extremely irregular, there being two deep, broad grooves in the external condyle, separated by a broad dense, bare, sclerotic bony surface. The walls of these grooves are of spongy bone and show surface absorption. The fibrous tissue filling them is mature in its deeper portions and necrotic along the surface. In the mesial groove an adhesion is attached. The floor of the intercondylar space is filled with radiating fibrous tissue, the sides being of dense, bare bone which on the lateral wall is newly formed. The mesial condyle is irregularly depressed by absorption of the bony trabeculæ. Bony surface spongy, showing evidence of absorption and little new bone formation. The fibrous covering is thick and dense in the deeper portions and necrotic along the surface, except about the middle where there is a suggestion of differentiation into a cartilaginous layer.

The newly formed joint is a poor one due no doubt to the infection, marked thickening and ossification of the capsule favors ankylosis, but the ends of the bones show an endeavor at new joint formation.

56-day experiment. Dog No. 33. Knee. Resection with saw and chisel. No flap used. Cartilage not removed from the patella. Skin wound slightly infected requiring daily dressings. At end of 56 days flexion is complete; extension to 90 degrees. Patella retracted above condyles.

Necropsy. A thin capsule in the region of the quadriceps tendon has reformed. The tibiopatellar tendon had given away, the ends being retracted. There is a small joint cavity present. The anterior and inferior surfaces of the condyles are covered by a fibrous layer. In the region of the joint cavity, the external condyle is partly bare but largely covered by degenerated fibrous tissue. The internal condyle is completely covered by fibrous tissue. The articular surface of the *tibia* which involves the posterior part of the upper end has been cut obliquely downward and backward and is completely covered by fibrous tissue. The joint cavity is 2½ cubic centimeters wide and 1 cubic centimeter anteroposteriorly. Its lining, though irregular, is smooth and shiny.

Microscopic examination. Tibia. Transverse section in region of joint cavity. There is a considerable depression in the region of the external tuberosity. The tibial crest is low and rounded off. There is a fibrous covering varying in thickness over the entire extent of the surface. Over the mesial half and crest it consists of irregularly arranged, rather mature fibrous tissue, but over the lateral surface there is a dense, mature band running parallel to the bony cortex, which is œdematous and somewhat necrotic along the joint cavity. The bone is spongy and contains normal marrow in the depressed region of the lateral tuberosity but a thin irregular cortex is forming over the elevated portion. At the lateral margin, there is a strip of cartilaginous covering which has evidently formed from unremoved articular cartilage. No osteophytes about the edges.

There is a fibrous covering parallel to a portion of the surface of tibia resembling a surviving portion of a flap but no flap was used in this experiment.

60-day experiment. Dog No. 16. Elbow. Articular surfaces removed with a chisel. Bandage removed after 9 days. Wound clean. Sixty days, range of motion almost complete. Dog killed.

Necropsy. On opening through the line of the joint the capsule is found moderately thickened. The joint cavity is partitioned by a band running anteroposteriorly along the intercondylar groove. The cavities are also reduced in size by the ingrowth of fibrous tissue about the margins of the bony ends. The extent of joint surface of the condyles is considerably less than normal due to the fibrous overgrowth from the sides. About half of the remaining portion is formed by irregular islands of bare, dense polished bone which are most extensive along the lateral condyle. The other half is covered by a thin layer of fibrous tissue with the cut surface of the partition running irregularly along the intercondylar groove. The articular surface of the *ulna* is formed largely by smooth, dense, bare bone but about the sides of the ulnar ridge is a rough fibrous covering. The partition runs along the joint between radius and ulna. The articular surface of the *radius* is partly obliterated in the region of the radio-ulnar joint. The surface of the radial end is bare and dense over the mesial portion, but has a fibrous covering over the lateral portion.

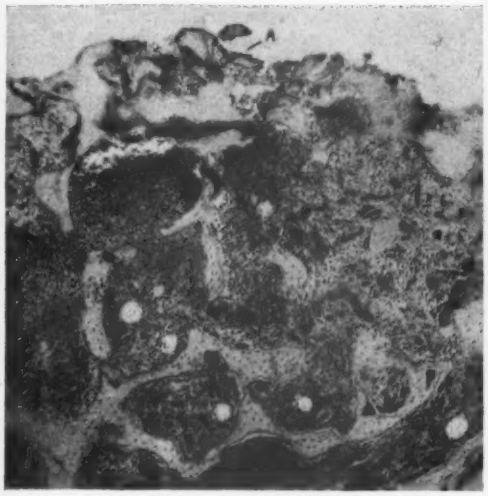

Fig. 1. No flap. 8-day experiment. Dog No. 3. Moderately infected. Necrosis and sequestration along left half of surface, *A*. New bone formation below on right, *B*.

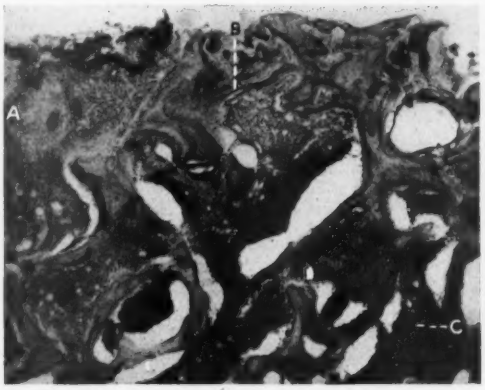

Fig. 2. Knee-joint. 14-day experiment. Dog No. 73 Bare condylar surface at point of pressure with *A*, fibrous cortical marrow and *B*, beginning cortical sclerosis; *C*, underlying normal marrow.

Microscopic examination. Humerus. Transverse section through anterior portion of condyles of *humerus* shows a very irregular articular surface. There is a slight internal marginal exostosis. The prominent portion of the internal condyle has a dense bare bony surface. The intercondylar groove is deep and filled with mature fibrous tissue from which adhesions come off. The external condyle has a thick irregular fibrous covering and has an irregular cortex of newly formed bone. The irregular surface of the joint cavity extends laterally to a little beyond the middle of the condyle. A broad fibrous adhesion is also given off from this surface. The fibrous covering is somewhat villous with degeneration of the projecting masses.

Ulna. The surface of the ulnar ridge is composed of dense, bare, smooth bone on either side of which the articular surface is depressed, irregular and covered by a fibrous layer which has a necrotic joint lining except for the cut surface of the fibrous partition laterally.

Radius. There are fibrous adhesions about the external surface of radial head where cartilage is removed. Cartilage is preserved where it articulates with the ulna. The surface of the end is bare and polished mesially and covered by a fibrous layer running irregularly parallel to the surface laterally. The underlying bone of all of the articular surfaces contains normal bone marrow extending out to the surface.

There is marked thick fibrous covering of most of the articular surface of all 3 bones. The irregular bare areas at the points of pressure are sclerotic. Adhesions are numerous. The irregularity of joint surface, fibrous covering and adhesions suggest the possibility of an infection, but there were no evidences of it during the healing of the wound.

60-day experiment. Dog No. 89. Knee-joint. Fairly extensive resection of tibia and femur; articular surface of patella undisturbed. No record of length of time immobilized. Wound clean, limb not used at the time animal was killed. Mobility slight, not more than 15 degrees.

Necropsy. There is a small joint cavity between the patella and femur. The articular cartilage of the patella is intact. The tibiopatellar tendon is adherent to the anterior articular surface of the femur, obliterating the upper recessus. On cutting between the tibia and femur, a thick capsule is found and a small central irregular joint cavity opened into. The tibia is mesially displaced so that the external condyle of the femur overrides the eroded lateral tuberosity of the tibia. The mesial condyle is destroyed by erosion against the tibial crest. There is extensive new bone formation about the side of the tibia forming a ledge beneath the overriding external condyle of the femur. The articular surface of the tibia is formed of irregular ridges and grooves of dense, bare bone with ragged fibrous tissue about the margins. The surface of the eroded mesial condyle of the femur has a dense, sclerotic, bare, bony ledge which articulates with the opposing sclerotic, tibial surface. The mesial portion of the internal condyle, intercondylar groove, and external condyle have an irregular spongy, bony surface with a varying amount of fibrous covering.

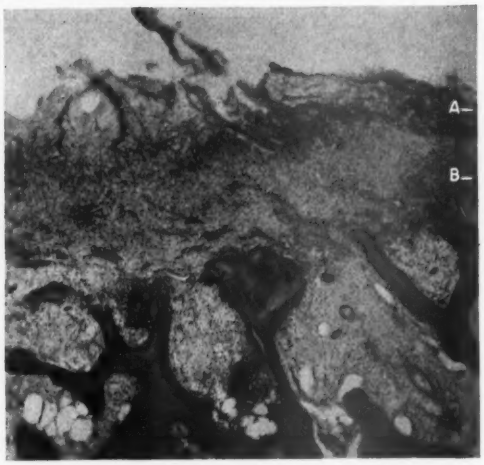

Fig. 3. No flap. 14-day experiment. Dog No. 73. Condyles at points of little pressure; *A*, fibrinous and *B*, fibrous covering.

This joint shows the bad influence of subluxation on the mobility and character of joint formation.

74-day experiment. Dog No. 86. Knee-joint. Extensive resection of tibia and femur; patella undisturbed. Dressing removed eighth day. Wound clean. Limb little used. About 65 degrees of motion in joint at time animal was killed.

Necropsy. The *tibia* and *fibula* are displaced backward and inward and angulated outward. There is a thick fibrous repair of the lateral incisions in the capsule. There is a cavity between patella and femur. The surface of the patella is eroded mesially from contact with a ridge on the underlying femur. The tibiopatellar tendon is adherent to the anterior inferior surface of the femur. There is a small joint cavity between the anterior half of the tibial articular surface and the posterior half of the flexed femoral condyles. The joint surfaces are very irregular. There is a dense irregular wedge of bone running anteroposteriorly on the tibia which fits into a similar dense groove on the femur. Their surfaces are polished. The remainder of the joint surfaces are small and covered by fibrous tissue.

Microscopic examination. Transverse section through *femur* beneath patella shows a fibrous covering parallel to the bony surface which is spongy and shows some superficial lacunar absorption. A synovial lining is present at the sides of the cavity and over part of the femoral surface of the cavity.

A transverse section through the condyles of the femur shows a moderate thickening of the capsule and small exostoses at the joint margins. The condyles of the femur are very deeply grooved and the spaces are filled with fibrous tissue. The lateral tuberosity of the *tibia* is likewise grooved and the fibrous tissue filling the defects is adherent to that filling the grooves in the femur, thus obliterating largely the lateral portions of the joint. The wall of the intercondylar groove and lateral wall of the internal condyle are bare and sclerotic, and articulate with a similar bare dense prominence of the tibial crest. There is a small dense bare bony projection on the mesial surface of the lateral condyle opposed by a similar surface on the tibia. A slight depression in the intercondylar groove is covered by villous masses. The fibrous lining of the joint is very irregular, the walls are slightly necrotic and villous.

There is marked sclerosis of the contacting surfaces but advanced erosion of the condyles and tuberosities and irregular broad adhesions. As yet there is little ossification proceeding from the bony surfaces into the adhesions attached to them. Articular cartilage of the patella largely eroded.

79-day experiment. Dog No. 65. Knee-joint. Articular surfaces removed with scroll saw. Bandages removed ninth day. Wound clean. Twenty-fourth day limb flail, patella movable. Lateral mobility and full range of motion in joint. Limb not used in walking. Little improvement in function at time the animal was killed.

Necropsy. Joint quite flail. Incision through the capsule shows a joint cavity between femur, tibia and patella. The recessus above the patella

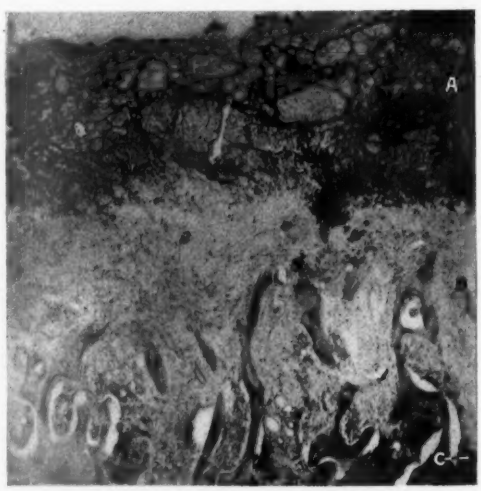

Fig. 4. No flap. 14-day experiment. Dog No. 73. Surface on tibia opposing that of condyle shown in Fig. 3. *A*, fibrinous layer; *B*, fibrous layer; *C*, normal layer.

is obliterated. A large sheet of fibrinous tissue covers the external condyle of the femur and is adherent to the capsule about the femur anterolaterally. This is adherent to the fibrinous covering of the anterior surface of the tibia by a thin fibrinous band. Fibrinous flakes and villi are distributed irregularly over the bony synovial surfaces. In places fibrous organization of these masses is occurring. The articular surface of the *femur* is covered by a layer of fibrous tissue except the posterior portions of the condyles and the anterior surface in contact with the patella. These are the points of pressure and their bony surfaces are bare, dense and shiny. The surface of the *tibia* is very irregular. The internal condyle of the femur has eroded the internal tuberosity of the tibia making an irregular groove. The external tuberosity is less extensively eroded. The points of contact with the condyles are dense, shiny, smooth and wavy. A ridge of bone partly covered by fibrous tissue extends along the posterior margin of the point. The tibial crest has been destroyed. Extending inward and backward from the region of the tibial crest on the surface of the internal tuberosity is an irregular surface where the cortex has been absorbed and covered by a deep layer of reddish granulations. The synovia of the capsule is shiny and hæmorrhagic. The surface of the patella is bare and rough. There is some overgrowth of fibrous tissue from the margins.

Microscopic examination. Transverse section through anterior surface of femoral condyles above point of pressure. The smooth articular surface is covered by a fairly regular layer of fibrous tissue running parallel to the bony surface. It has a synovial covering at the sides and over part of the external

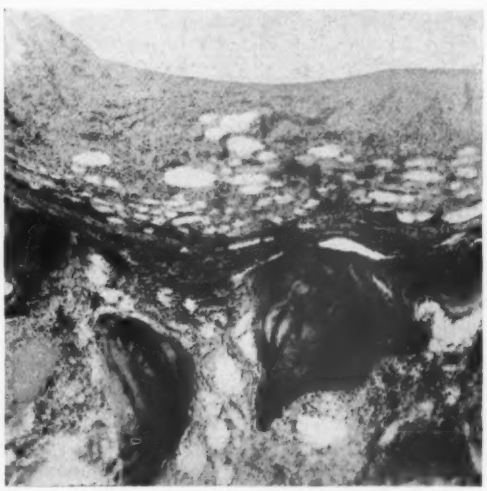

Fig. 5. No flap. 56-day experiment. Dog No. 33. Little pressure. Fibrous layer parallel to surface.

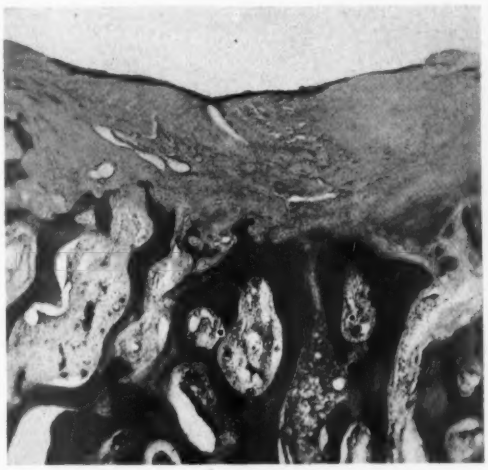

Fig. 6. No flap. 76-day experiment. Dog No. 65. Joint surface of femur opposite the patella. Fibrous covering and no cortical sclerosis.

condyle. The rest of the surface at point of contact with the patella and tibiopatellar tendon has a necrotic covering. The bony surface is spongy, with evidence of lacunar absorption of the ends of the trabeculæ and a small amount of cortical new bone formation. The normal bone marrow extends out to the bony surface (Fig. 6).

A transverse section passing back of the middle of the femoral condyles shows a bare, smooth bony surface with a moderate amount of irregular new bone formation in the cortical marrow spaces.

There has been no weight bearing by this surface; consequently no sclerosis. The fibrous covering with a modified synovia lining is in marked contrast to the surface in the weight-bearing region.

91-day experiment. Dog No. 15. Elbow. Fairly extensive removal of articular surfaces. Bandage removed ninth day. Wound clean. Dog used limb in walking and there was full range of motion.

Necropsy. The joint capsule is restored. Practically the entire joint cavity is present. An adhesive band extends from the groove in the middle of the condyle of the humerus to the capsule on the lateral surface of the olecranon. The recessus of the joint about the bony articular surfaces is partly obliterated and bridged by adhesive bands. The articular surface of the humerus is smooth and shiny over the greater portion of the condyles (Fig. 7). Anteriorly there is a blue transverse streak resembling cartilage at its margin. Posteriorly and about the margins of the internal condyle, there is marked

Fig. 7. No flap. Elbow. 91-day experiment. Dog No. 15. Showing bony part *A*, and *B* fibrous articular surfaces.

destruction of the cortical surface and a fibrous covering is present. There is a narrow irregular longitudinal eroded area over the external condyle in which the adhesive band from the olecranon is inserted. The mobility of the radio-ulnar joint is limited. A thin fibrous band partitions it from the main joint about the margins of the radial head. Most of the articular surface of the ulna is bare, dense, and shiny. Erosions about the margins. Some cartilage is present over the coronoid process. The surface of the radial head is bare and dense in the center, covered by fibrous tissue at the periphery.

Microscopic examination. Humerus. Transverse section through articular surface of humerus. The shiny bony surface of the external condyle shows cortical sclerosis and has no fibrous covering (Fig. 8). In the region of the groove cortical bone is absent and there is a thick fibrous covering which is continuous into the underlying marrow spaces. Over the internal condyle and intercondylar groove there is a fibrous covering with very little cortical sclerosis (Fig. 9). The underlying marrow is not fibrous. Evidently the fibrous marrow which formed earlier has been replaced by the normal marrow tissue. The marrow spaces beneath the dense bare cortex seems to be more fibrous.

On the *ulna* the dense central bony surface is bare and smooth. The underlying marrow spaces are small and slightly fibrous. At the margins the bony surfaces are depressed and covered by a thick layer of fibrous tissue which is continuous with the capsule. It extends slightly into the underlying marrow spaces. Small osteophites are seen about the margins and there is some periosteal new bone formation along the sides.

This is a fairly well constructed new joint showing typically the two varieties of articular surface which may form.

120-day experiment. Dog No. 49. Knee. Articular cartilage and a moderate amount of bone removed with a saw. No flap used. Length of immobilization not accurately recorded. Wound clean. At end of 120 days about 120 degrees of motion. Leg held in flexion. Patella about 1 inch above line of the joint and fixed.

Necropsy. On opening the joint, cavities are found in the region of the condyles. Tibial crest

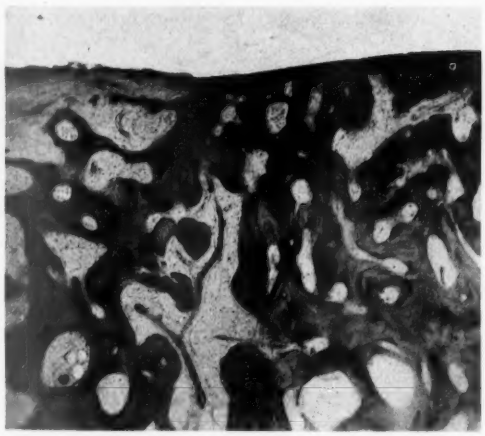

Fig. 8. No flap. 91-day experiment. Dog No. 15. Junction of fibrous and bony articular surfaces. External condyle of humerus.

loosely adherent to the intercondylar groove of femur. A thick fibrous covering over margins of condyles and intercondylar groove which apparently has grown in from the sides. Capsule is adherent to the anterior surface of the femur. Upper recessus obliterated. The prominent posterior surface of the condyles is bare, irregular and sclerotic. There is marked grooving and undermining by the fibrous tissue about their margins. Fibrous union between patella and femur. Tibial crest well marked but irregular. The margins of the tuberosities are covered by fibrous tissue ingrowth from the capsule. Their centers are bare and a dense sclerotic bony cortex has formed, posterior to which the cortex is eaten away by granulations. Some lipping about the margins of tibia.

Microscopic examination. Tibia. Transverse section. Moderately thin fibrous covering over most of a fairly regular joint surface. Covering arranged irregularly parrallel to the bony surface. Surface of lateral half of external tuberosity formed by dense bare bone. No joint cavity lateral to it. Cut surface of adhesions are seen about tibial crest. A sharp sclerotic bare prominence about middle of mesial tuberosity. The rest of the surface is slightly depressed and has a spongy bony lining which shows a slight tendency to ossification of the covering. Along the tibial crest ossification of the attachment of the adhesive band has taken place. There is some ossification of the thickened capsule at the sides.

Femur. Transverse section through condyles. Irregular condylar surfaces with a number of small grooves filled with fibrous tissue, the intervening ridges being of bare, dense bone. Intercondylar groove covered by a fibrous layer giving off an adhesion to the tibial crest. Slight ossification of

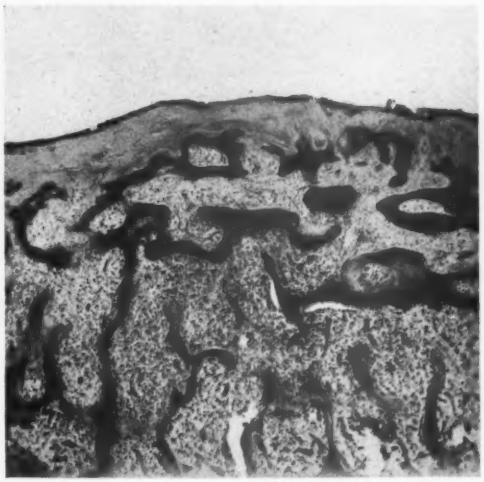

Fig. 9. No flap. 91-day experiment. Dog No. 15. Internal condyle. Fibrous covering with slight cortical new bone formation.

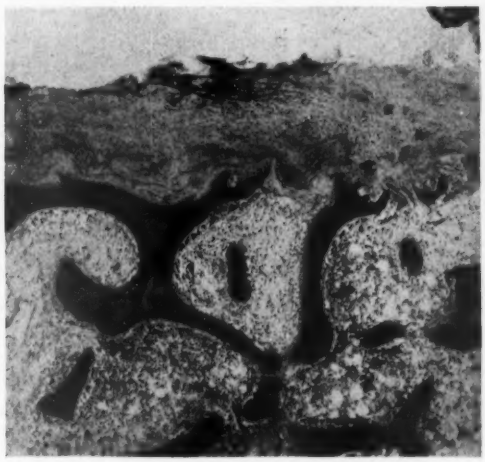

Fig. 10. No flap. 128-day experiment. Dog No. 76. Fibrous covering of condyle of femur after extensive resection. Flail joint with little pressure.

the fibrous tissue filling the grooves is occurring along the surface. Fibrous covering along internal condyle shows a tendency to differentiation into an articular cartilage.

Capsule thick, adherent to femur anteriorly and has a tendency to ossify. Slight tendency to ossification of the fibrous coverings of the joint surfaces, but also a tendency of the same to change into articular cartilage. Despite these features a fair degree of mobility was preserved.

120-day experiment. Dog 45. Knee. Tibiopatellar tendon cut to expose the joint and later sutured. Resection made with a saw. Limb immobilized 2 weeks. Wound clean. Limb not used in walking. At end of 120 days only 10 degrees of motion.

Necropsy. Femur and *tibia* united by a firm thickened capsule. On cutting through the line of the joint two narrow dime sized cavities are found in either condylar region separated by the tibial crest which fits into the intercondylar groove along the middle portion of which is a small cavity communicating with that over the median condyle. Anteriorly and posteriorly there are exostoses from the ridge on the tibia and fibrous adhesions to the femur. The patella is displaced three-fourth inch upward and has a bony union to the femur. The upper recessus of joint is completely obliterated. The articular surface of the femur is partly covered by fibrous tissue which has apparently grown in from the capsule and partly by granulation tissue which seems to have come from the bone marrow. The cortical surface is very dense and bare over the condyles. The depressions on either side of the crest are very rough and covered by granulation tissue which seems to have come from the underlying marrow. The entire capsule is greatly thickened and hard in places having the consistency of bone and forming a rim about the margin of the joint.

Microscopic examination. Femur. Transverse section through condyles. Marked fibrous thickening about the sides of the joint with an independent center of ossification on either side. Slight periosteal proliferation along side of lateral condyle. The joint surface extends laterally into fibrous tissue beyond the bony limits where the lining is thickened, irregular and necrotic. The inner portion of the mesial condyle is made up of irregular, jagged, spongy bone covered by an irregular fibrous layer. The joint surface is interrupted mesially by a fibrous band; in the rest of its extent it is very irregular and necrotic. No semblance of an endothelial lining. Underlying spongy bone shows ossification advancing into the fibrous covering in a few places as if attempting to form a continuous bony cortex. At the lateral border of the condyle the bony surface is bare and sclerotic. External to this at the margin of the intercondylar groove the surface has a fibrous covering with a spongy bony cortex forming below. The middle of the intercondylar groove is dense, bare, polished bone, the superficial cells of which have broken down, leaving the lacunæ vacant. External condyle somewhat more depressed than the mesial. It has a thick fibrous covering over its mesial portion with underlying

Fig. 11. No flap. 51-day experiment. Dog No. 54. Immobilized entire period. Shows developing ankylosis.

spongy bone, with scattered areas of surface proliferation. The fibrous covering is wavy and dense next to the bone and extremely necrotic and irregular along the surface. There is a sharp bony projection with a bare, dense cortex at the crest of the condyle. External to this there is a groove in the condyle covered by fibrous tissue, the floor of which shows ossification. The lateral margin of the condyle is of bare, dense bone.

A joint cavity is still present in spite of almost complete ankylosis. Marked tendency toward thickening of the capsule and lipping. At places of pressure the cortical bone becomes smooth, dense, and shiny. The fibrous covering has mostly grown out from the marrow spaces. Little tendency to ossification of the fibrous covering.

Fig. 13. Pedunculated flap. 9-day experiment. Dog No. 5. Triangular shaped pedicle of flap the necrotic apex, *A*, of which lay between the radius and external condyle. Base, *B*, alive because not compressed.

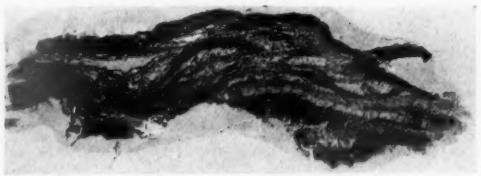

Fig. 12. Pedunculated flap. 5-day experiment. Dog No. 48. Section out of the remaining bridge of flap along the intertubercular ridge of tibia extending from one perforation to the other.

128-day experiment. Dog No. 76. Knee. Extensive resection. Patella not disturbed. No flap used. Bandage removed on seventh day. Wound clean. Limb little used. Range of motion about 130 degrees.

Necropsy. Joint flail. Inward and backward displacement of the *tibia*, bringing the external condyle of *femur* in front of the fibula and the internal condyle in back of the tibiopatellar tendon. A joint cavity lined with a rough, villous, granulating surface is found. Entire tibial surface covered by a rough fibrous layer. Small islands of eburnated bone on each tuberosity. There is a fibrous covering over all of the femoral surface except a small projecting area over the internal condyle where it is in contact with the tibia. External condyle which is free from pressure is covered by loose granulations. No cavity here.

Microscopic examination. Femur. Transverse section through condyles. There is an even joint surface covered in the condylar regions by a thin fibrous layer (Fig. 10). Over the intercondylar groove the fibrous covering is much thicker and presents the cut surface of two adhesive bands. There is considerable fibrinous exudate and a few organizing tags along the surface of the joint. In other places where there was less pressure as along the sides of the adhesions there is sort of a synovia present. The cortical bone is spongy and shows little new bone formation and much absorption of the superficial trabeculæ along the entire surface except at the mesial side of the internal condyle where a bare, dense, spicule projects. The joint lining over the capsule at either side is uneven and formed largely by necrotic tissue covered by exudate.

The joint is flail. There is a large joint cavity extending up above the patella. The walls are very shaggy with much fibrinous exudate. This shows particularly well the changes which occur when the limb is not used for weight bearing. There is a fibrous covering of almost the entire bony surfaces and no sclerotic cortex except in one or two small areas over the internal condyles. The

Fig. 14. Pedunculated flap. 10-day experiment. Dog No. 51. Margin of flap which was not compressed. Deeper portion, *A*, alive. Superficial necrosis.

Fig. 15. Pedunculated flap. 10-day experiment. Dog No. 51. Edge of flap bordering on perforation, *A*, showing necrosis.

condition of the joint is much like that to be expected following arthroplasty in the upper extremity of man.

RÉSUMÉ OF CHANGES FOLLOWING NO-FLAP OPERATIONS

In reviewing the group of experiments it will be seen that the changes which occur in the average joint according to age and the previously enumerated modifying influences are somewhat as follows:

From the operation there is extravasation of blood into the cavity which partly fills the recesses and covers over the necked ends of the bones except at the points of contact and pressure against the opposing bone where it is either prevented from deposition or is eroded by motion. The incisions in the capsule heal rapidly and any defects, as in the lateral portion of the knee in case of the flap operation, are very rapidly repaired. The bone marrow along the joint surface is quickly transformed into fibrous tissue and the cells of many of the traumatized surface trabeculæ undergo necrosis and absorption. The transformation continues and varies in the different parts of the joint according to the presence or absence of pressure upon the bony surface.

Where there is absence of pressure, a fibrous covering rapidly grows out from the open spaces of the ends of the bones and gradually replaces the layer of resolving blood clot (Figs. 3 and 4). If early motion is established a joint cavity will be maintained and there will be no adhesions between the opposing fibrous surfaces. There is a wide range in the thickness of this fibrous layer. In general the wider the separation of the bony surfaces the thicker it will be and it is especially apt to be marked in the intercondylar groove and about any rounded margins and recesses which are practically free from pressure. The cortical bone of such regions shows no tendency to sclerosis, the marrow spaces remaining open. The ends of some of the superficial trabeculæ, as a result of the traumatism, undergo necrosis and absorption.

Over the prominent portions of the condyles and tuberosities which are in contact with and subject to pressure by the opposing bone the surfaces remain bare, and become smooth from the wearing away by friction of the uneven projecting trabeculæ (Fig. 2). Some of this bone dust is ground into the open intertrabecular spaces along the surface. New bone formation occurs and goes on rapidly to

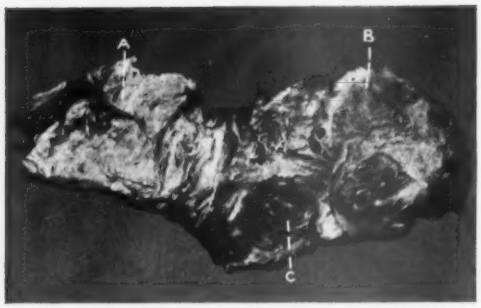

Fig. 16. Pedunculated flap. 16-day experiment. Dog No. 82. Knee-joint opened. Patella and tendon reflected forward, *A*; and femoral condyles backward, *B*; exposing articular surface of tibia covered by flap which has broken down over condyles more markedly over lateral, *C*, which is nearer the pedicle of flap.

the formation of a dense smooth, cortical layer, which becomes the supporting or weight-bearing portion of the joint. The more extensive and perfect the contact of the bony ends, the greater the range of motion and the less extensive the resection, the greater the area of bare, bony surface will be. The extent of this smooth, dense, bare surface is variable. It is greatest where the resection is least, the contact between the ends broad and perfect and the mobility marked.

These two types of surfaces are well marked by the end of the third week. The subsequent changes are somewhat as follows:

1. In the regions subject to little or no pressure the covering of fibroblasts gradually changes into mature fibrous tissue. The intertrabecular spaces near the surface usually become refilled with normal bone marrow. The cortical bone remains spongy and not infrequently grooves filled with fibrous tissue form. Where pressure is absent, the cells and fibers may be arranged parallel to the surface and resemble very closely surviving portions of an interposed flap (Fig. 5). With time and usage the various portions of the joint surface approach more nearly the same level and the areas with a fibrous covering are subjected to more pressure. This produces a variety of changes in the fibrous layer. The superficial portion becomes more or less necrotic with few nuclei and faint staining properties. The deeper portion shows little necrosis but the arrangement of the tissue is altered. The cells and fibers are either irregularly distributed or radiate at right angles to the joint surface, decreasing in frequency and staining power as the surface is approached. In the older experiments this change had advanced to the point where an imperfect articular cartilaginous covering had formed (Fig. 27). Villous tags are frequent about the margins and from the capsule and are sometimes found attached to the articular surfaces of the ends of the bones.

A variable number of adhesions are formed. For the most part they are about the edges, in the joint recesses and along the intercondylar groove in which case they may partition the joint cavity. The upper recessus of the knee-joint is usually obliterated or a separate cavity may be left between the patella and the femur, but the surfaces always have a covering of fibrous tissue without sclerosis of the underlying cortex as the pressure in this region is not sufficient to produce the sclerosed bare, bony surface (Fig. 6). Sometimes a fairly good endothelial lining is formed, especially along the surfaces of the adhesions and pockets where there is no pressure (Fig. 28).

The changes in the bare and sclerosed areas are variable. With age they usually show a tendency to decrease in size being gradually absorbed about the margins and replaced by the overgrowing fibrous layer. However, this change is usually a slow one and none of our experiments were sufficiently old to show the completion of the process. In some specimens the areas were stationary as no evidence of replacement or spreading could be detected upon microscopic examination of the junction of the fibrous and bony surfaces. Sometimes actual spread of the sclerosed area was seen about portions of its margins.

The joint cavity was practically always decreased in size especially in the case of the knee-joint. The capsule was usually thickened and exostoses were present about the joint margins, especially at the insertion of the capsule. Where resection was fairly extensive, weakening the articular portion of the ulna or the condyles of the tibia, considerable new bone formation occurred along the periosteal surface of the end.

The range of motion varied with the various factors enumerated but in general it was considerable. It was most marked in the elbow as in the 60-day experiment, Dog 16, where it was almost complete. The results were much poorer on the knee although fair mobility sometimes resulted as in the 91-day experiment, Dog 15, where the animal used the limb. Where extensive resection of the knee was performed wide range of mobility but a flail and useless joint was usually obtained. Prolonged immobilization completely altered the picture as shown by Experiment No. 54, 51 days old, where there was *complete fibrous and forming bony* ankylosis (Fig. 11).

Infection interfered with the new joint formation but when mild was not incompatible with the establishment of a certain amount of motion.

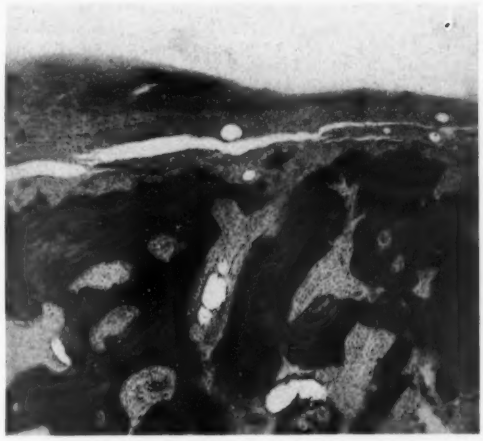

Fig. 17. Pedunculated flap. 42-day experiment. Dog No. 78. Covering, *A*, of condylar surface not derived from flap.

PEDUNCULATED FLAPS

Helferich, who first used the pedunculated flap, did so with the hope that the interposed muscle would remain alive and inhibit the recurrence of ankylosis. Little experimental evidence as to the behavior of the flap was offered by those who early extended this method of performing arthroplasty. Murphy and Neff thought from a very few experiments on dogs that a kind of bursal sac formed in the flap, the walls of which became attached to the ends of the bones and formed the lining of the joint.

Payr advanced the theory that the joint cavity forms in the flap from degeneration and hæmorrhage into its central portions after the method described by Ledderhose for the development of a ganglion. Smaller cavities arising in this way become confluent and form one large joint space. Sumita working under Payr's direction thought he confirmed the theory by experiments on animals.

Allison and Brooks, in a very careful study of the fate of various substances placed in the upper recessus of the knee-joint between the patella and femur, found that pedunculated flaps except a small portion of the pedicle broke down and were completely absorbed within a short time. The articular surfaces of this region which had been denuded of cartilage and bony cortex were rapidly covered by a layer of fibrous tissue which grew out from the marrow spaces. No new bone formation occurred along the surface in any of their experiments. They made the mistake of assuming that the changes in the entire joint were the same as those occurring in the upper recessus without taking into consideration the differences in function and pressure to which this and the tibiofemoral portion of the joint are subjected.

Hohmeier and Magnus experimented on the knee-joints of rabbits and concluded that the pedunculated flap survived and became attached to the ends of the bones, splitting through the middle portion and forming a new joint cavity within its substance.

Thus we see that there is wide variation of opinion as to the part played by the flap and little information about the changes which go on in the articular surfaces of the bones.

PEDUNCULATED FLAP EXPERIMENTS

Fifteen experiments were performed, 8 of which were on the knee and 7 on the elbow. Five were infected in varying degrees.

5-day experiment. Dog No. 48. Knee. Tibiopatellar tendon cut and resutured after an extensive resection of the joint and the interposition of a pedunculated fascial and muscle flap between femur and tibia, and femur and patella according to the technique previously described.

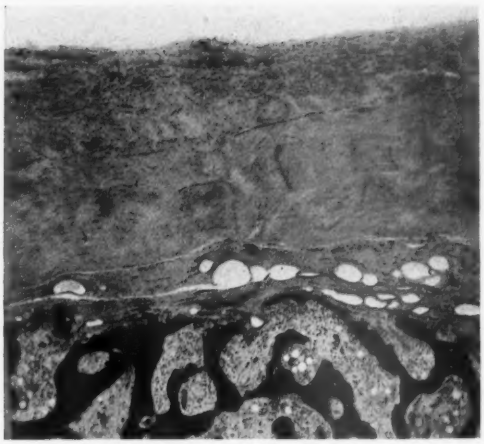

Fig. 18. Pedunculated flap. 42-day experiment. Dog No. 78. Flap preserved over dislocated articular surface of tibia not subjected to pressure.

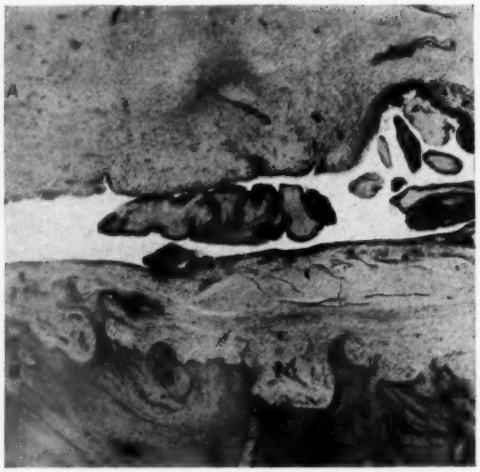

Fig. 19. Pedunculated flap. 146-day experiment. Dog No. 66. Bursa-like cavity posteriorly between flap, *A*; and tibia, *B*; but outside of the main joint cavity.

Dog killed on fifth day. In giving the ether the joint was pulled open. The tibiopatellar tendon had previously given way and retracted the patella upward.

Necropsy. The flap under the patella is intact. The surface of the *femur* is mostly bare, in places granulations are growing out. The flap over the tibia is intact and molded to fit the space between the two bones. Two depressions with necrosis of the flap are seen at points of pressure from the condyles.

Microscopic examination. Section of flap beneath patella is smooth next to patella, rough and necrotic next to the femur. It is composed of a dense fibrous band in its central portion with loose and more richly cellular structure peripherally. Considerable necrosis is seen throughout the flap with cellular proliferation especially along the surface next to the patella. Most of the blood vessels seem alive but contain no cells. No hæmorrhages or cavities are seen.

A section was cut transversely through the flap over the tibial crest from one necrotic area to the other (Fig. 12). The free surface of the flap is necrotic and covered with débris. The tibial surface is adherent to the bone and partly alive, the muscle content in this region showing necrosing fibers with well preserved and hypertrophying interstitial tissue. Old capillaries and small blood vessels are seen in the middle of the flap, filled with fibrinous exudate. Next to the bone a few invading capillaries are present.

This specimen shows how the flap breaks down in its entire thickness at points of pressure; also how the flap becomes attached to the surface of only one bone. The nutrition of the surviving portions of the flap is not preserved through the pedicle but by vascular ingrowth at its new attachments. An anteroposterior section through the mesial condyle of the femur shows a bare, somewhat polished, spongy surface with a superficial fibrous marrow. The cells of the superficial trabeculæ are necrotic.

8-day experiment. Dog No. 7. Elbow. Lateral incision. Triceps tendon not cut. Pedunculated flap interposed after removal of articular surfaces. Wound infected; dressed daily. Died eighth day.

Necropsy. An opening 1 cubic centimeter long leads into the joint at middle of incision. Capsule swollen. The flap has entirely disappeared except for a small portion of the base about 1 cubic centimeter long and ½ cubic centimeter wide which is disc-shaped and appears necrotic at its margin. About the periphery of the joint, granulations are growing out from the capsule. Articular surface mostly bare and rough from chiseling.

Microscopic examination. Humerus. Transverse section through mesial condyle. Along the articular surface the bone is bare. Leucocytic infiltration and some necrosis of the trabeculæ and beginning fibrosis of superficial bone marrow. Mesially where free from pressure there is a thin covering of granulation tissue with slightly fibrous marrow and a few newly formed bony trabeculæ in the superficial marrow spaces. Considerable cortical necrosis.

The findings are very similar to those in infected 8-day experiment No. 8 in which no flap was used.

9-day experiment. Dog No. 5. Elbow. Articular cartilage removed with a chisel from entire bony articular surface, the triceps tendon having been cut to facilitate exposure. A pedunculated flap of fascia from the lateral side was reflected over the radius and ulna and sutured at its margins. Wound clean. Dog died on ninth day.

Necropsy. Interposed flap adherent to the capsule about the entire circumference of the articular surfaces. About two-thirds of its central portion is broken down. The remainder is represented by a reddish débris which is closely adherent to the articular surfaces. The living peripheral portion of the flap thins out as it approaches the central necrotic portion, similar to a semilunar cartilage. The living peripheral portion of the flap is easily separated from the ends of the bones. The portion of the flap in the coronoid fossa is necrotic.

Microscopic examination. Triangular shaped section was excised laterally through pedicle of flap at the side of the joint and through the surviving marrow portion, extending inward for a short distance between the exterior condyle and the radial head (Fig. 13). The flap is broad toward the base where it is attached to the capsule, gradually narrowing toward the apex, where it is necrotic and somewhat hæmorrhagic. As the base is approached, it becomes less necrotic until near the capsule most of the flap is alive and is being invaded by a rich network of fibroblasts and invading capillaries from the capsule.

A transverse section through the condyles shows the *humerus* covered in the intercondylar region by remnants of a thin necrotic flap held in position by a fibrinous exudate. The condylar surfaces are bare. As yet there is little cortical proliferation. The superficial marrow is fibrous.

The flap has nearly all broken down and the condition of the ends of the bones is practically the same as in a no-flap operation.

10-day experiment. Dog No. 51. Knee. Tibiopatellar tendon cut and sutured. Dog had distemper. Killed tenth day. Wound clean.

Necropsy. Wound clean. Incision in joint capsule healed. Tibiopatellar tendon reunited by a thin band of granulation tissue. The joint is opened through the previous incision. The remnants of the flap are adherent to the *femur* about the margins and along the intercondylar groove. Over the *tibia* there are two depressions in the flap, at points of contact with the condyles which are separated by the ridge of the tibial crest. The flap is necrotic over an area 1 cubic centimeter in diameter over the lateral tuberosity and very thin and partly broken down over the mesial tuberosity, leaving a small perforation. The remainder of the flap

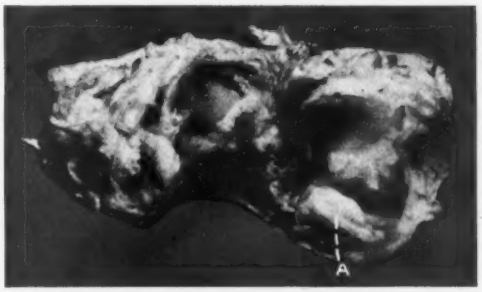

Fig. 20. Pedunculated flap. 161-day experiment. Dog No. 3. Elbow-joint opened from front showing smooth bony surface without arthritis and surviving pedicle of flap over edge of external condyle, *A*.

seems to be alive and adherent to the tibia. The pedicle is indistinguishably fused with the capsule laterally and the free margins of the flap with the capsule elsewhere. The distal end of the flap, which covers the internal tuberosity shows less necrosis than the proximal portion over the external tuberosity.

The amount of necrosis seems dependent upon the amount of pressure; the external condyle in this case being longer than the internal caused more destruction.

The upper recessus of the joint is obliterated. The transplant under the patella is alive and adherent to both patella and femur. The condyles of the femur are reddish and covered by small irregular granulations.

Microscopic examination. Transverse section through condyles of *femur* shows surface of external condyle polished, smooth and bare. Bone dust in the crevices along the surface. Marked subcortical new bone formation. In the intercondylar groove, there is a new fibrous surface covering, with spongy walls and absorption of the superficial trabeculæ. The internal condyle has a thin fibrous covering, shows absorption of surface trabeculæ, fibrous marrow, and no cortical new bone formation.

There was pressure over the lateral tuberosity causing extensive necrosis of the underlying flap, but little pressure over the internal tuberosity, producing only a small area of necrosis.

A wedge shaped section of the flap was excised with the base over the anterior part of the tibia and the apex in region of the broken down portion over the middle of the tuberosity. The deeper portion next to the tibia is practically all alive, but as the free

Fig. 21. Pedunculated flap. 161-day experiment. Dog No. 3. Dense smooth bony joint surface.

Fig. 22. 161-day experiment. Dog No. 3. A typical articular cartilage formed over intercondylar region.

surface and extremities are approached it shows necrosis (Fig. 14). Bordering on the perforation it is completely broken down and thinned out (Fig. 15).

14-day experiment. Dog No. 2. Elbow. Articular cartilage and small amount of cortex removed from all three bones with a chisel after cutting the triceps tendon. Pedunculated flap of fascia interposed. Dressing removed and dog killed on the fourteenth day. Slight infection of the skin.

Fig. 23. Pedunculated flap. 161-day experiment. Dog No. 3. Typical articular cartilage re-formed.

Necropsy. Base of the flap intact. Incision into capsule healed. When joint is opened the flap is found adherent to the humerus and does not separate on disarticulation. In its middle portion between the condyles it is broken down posteriorly in almost all of its extent. Anteriorly it is loosely attached to the humerus and head of the radius. The articular surface of the *ulna* is covered by a necrotic fibrinous exudate. There is some proliferation of the capsule about the margins.

Microscopic examination. Longitudinal median section of posterior half of *ulna* shows a covering of new fibrous tissue with leucocytic infiltration especially along the surface. Underlying marrow slightly fibrous. Moderate number of newly formed trabeculæ along the bony surface.

A longitudinal section through the *radial head* shows the surface covered by cartilage except where it had been removed from the side and margin. In this latter region there is a fibrous covering with fibrous marrow in the underlying cancellous spaces. Slight necrosis of the exposed trabeculæ and in places newly forming trabeculæ. The surface which is still covered by cartilage has a thin interrupted remnant of flap over it. It is attached at one side by granulations invading it from the capsule.

Humerus. Transverse section through posterior portion of the condyles. The articular surface is covered by flap in its entire extent. At the sides

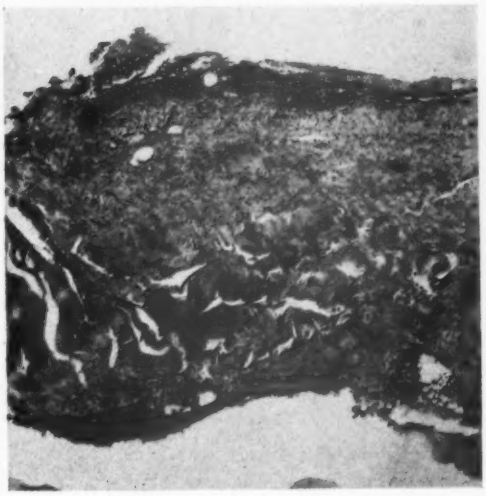

Fig. 24. Free flap. 5-day experiment. Dog No. 50. Uncompressed portion showing cell proliferation about margins.

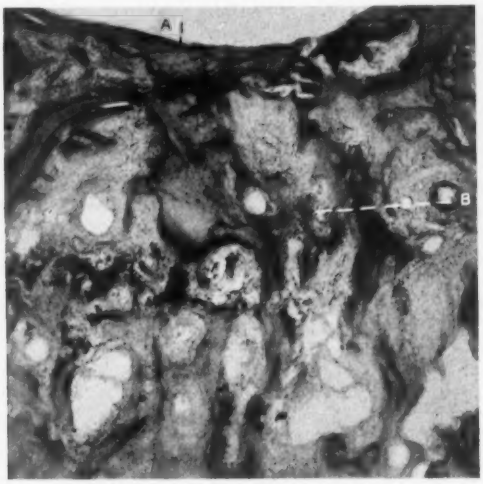

Fig. 25. Free flap. 14-day experiment. Dog No. 44. Region of tibial spine along surface, *A*; new bone formation beneath, *B*.

the flap is thick, adherent to the capsule, and only partly degenerated. Over the middle portion, it is very much thinner and almost entirely necrotic. In some places along the bony surface some of the deeper portion is alive. There is an outgrowth of fibrous tissue from the marrow spaces of the spongy bony surface which is invading and replacing the necrotic flap. In this region there is no evidence of cortical new bone formation.

14-day experiment. Dog No. 43. Knee. Tibiopatellar tendon cut and sutured. Pedunculated flap between femur and tibia. Bandage left on until animal was killed on fourteenth day.

Necropsy. The tibia is slightly displaced mesially on the femur. The line of incision is closed except for a small gap in the region of the tibiopatellar tendon. All traces of the pedicle of the flap are gone. On opening the joint and reflecting the quadriceps tendon laterally, it and the patella are adherent to the anterior surface of the femur, completely obliterating the upper recessus. The granulation tissue stays with the reflected tendon leaving a bare, granular, denuded bone. On separating the femur from the tibia a joint cavity 1.5 cubic centimeters in diameter is formed in the region of either condyle, where the flap was completely broken down, leaving necrotic, fibrinous shreds. The flap is intact about the margins and along the intercondylar ridge where relieved of pressure. The surviving portion of the flap along the tibial ridge is irregularly adherent to the intercondylar groove. Condylar surfaces covered in patches by fibrinous exudate and granulations between which is found denuded bone. The flap has blended with the capsule about the margins of the upper end of the tibia. There appears to be no more necrosis of the flap distal than proximal to the pedicle.

Microscopic examination. Transverse section through *femoral condyles.* The entire surface of the mesial condyle is bare and smooth with necrosis of the superficial bony trabeculæ and marked new bone formation. The superficial marrow spaces are markedly fibrous. The intercondylar groove is deep and still contains the attachments of the crucial ligaments from which there is a fibrous outgrowth along the surface. The lateral condyle is somewhat depressed and covered by a thin layer of the flap which has undergone complete necrosis. The bony surface is irregular with a fibrous covering growing out from the superficial fibrous marrow and replacing the necrotic remnants of the flap. Considerable new bone formation along the surface. At the lateral margin a portion of the flap pedicle fills the upper and lateral recessus of the joint and is reflected over the articular surface in which region it becomes necrotic.

Tibia. Transverse section through the articular surface. Remnants of the flap can be traced across the entire section. Laterally its pedicle is seen to be alive and proliferating and is bowed upward by a small inflammatory area. Where the lateral portion of the joint is reached, the flap rapidly thins out, becomes necrotic, and over the lateral half of the external tuberosity, which was opposed by the prominent mesial portion of the lateral condyle, entirely disappears. The mesial portion of the lateral tuberosity and lateral portion

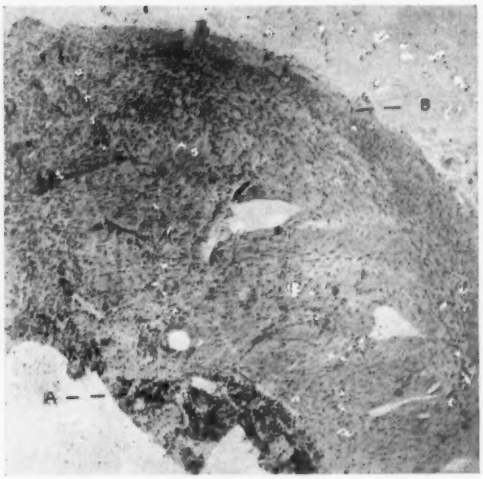

Fig. 26. Free flap. 15-day experiment. Dog No. 68. From intercondylar region where free from pressure deeper portion invaded by granulations, *A* from tibia. Superficial portion, *B* œdematous and necrotic.

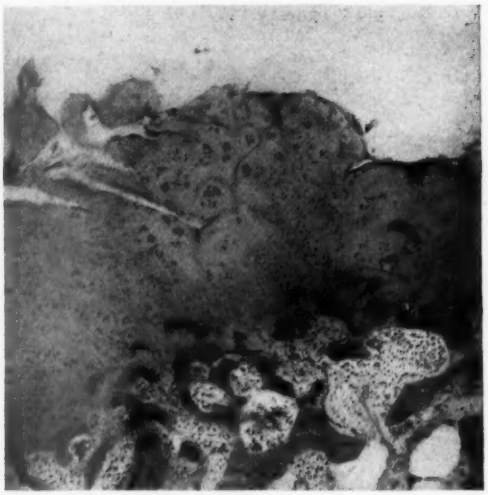

Fig. 27. Free flap. 119-day experiment. Dog No. 25. Elbow. Irregular cartilaginous articular covering reformed.

of the tibial spine, which were opposite the deep intercondylar groove, are covered by a thick ridge of flap which is completely necrotic, except perhaps in its deeper layers where there is a fibrous outgrowth from the bony surface which is growing into and replacing the necrotic flap. In the region of the mesial part of the tibial spine and lateral part of the mesial tuberosity which were in contact with the internal condyle of the femur, the flap has either disappeared or is very much thinned out, or completely necrotic. As the mesial margin of the joint is approached, the flap, which is still necrotic, increases in thickness and fills out the mesial recessus of the joint where it is very thick, folded, and partly alive. The bony surface underlying the necrotic flap has a covering of fibroblasts growing out from the marrow spaces which are filled with fibrous tissue. The bare bone where the flap has disappeared shows cortical new bone formation.

This experiment shows the interposed flap, where resection of the ends of the bones was only moderate, adherent to the tibia, undergoing necrosis and absorption, the bony surfaces at points of greatest pressure, where the flap has disappeared, being bare and sclerotic. Where the necrotic flap persists, the underlying bone has a covering of fibroblasts which are removing the flap. The necrotic flap covering the tibia acts much like the blood clot covering the ends of the bones in the 14 day experiment, No. 73, in which no flap was used.

16-day experiment. Dog No. 6. Elbow. Triceps tendon not cut. Pedunculated fascial flap interposed after removal of the articular surfaces. Plaster cast left on 6 days. Wound clean. Dog died on sixteenth day.

Necropsy. A slightly hæmorrhagic exudate escapes through an opening in the capsule anteriorly. The flap is largely broken down and its necrotic remnants cover the ends of the bones. The capsule is thickened. Organizing blood clots fill the recessus about the margins of the joint cavity. The articular surfaces have a reddish appearance.

Microscopic examination. Section made anteroposteriorly through mesial condyle of *humerus* shows the articular cartilage entirely removed. The bony surface is fairly smooth, the superficial marrow slightly fibrous and infiltrated with leucocytes. There is no fibrous covering growing out from the marrow. The flap extends from the margin over the posterior two-fifths of the articular surface. It is thick, and alive at its base, where it is attached to the bone. It becomes narrower as the interior is approached and the tissue is entirely broken down. No nuclei are visible except those of the leucocytes. A small amount of cortical sclerosis is seen along the anterior articular surface. There are very few necrotic bony trabeculæ.

While a considerable amount of the flap was still present it was much thinned out

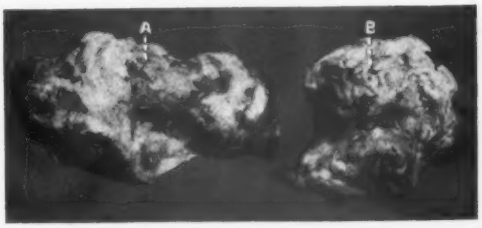

Fig. 28. Infected free flap. 129-day experiment. Dog No. 23. Elbow. Joint opened from in front showing villous arthritis with fibrous articular coverings.

and on microscopic examination was found to be necrotic.

16-day experiment. Dog No. 82. Knee. Extensive resection of joint. Pedunculated flap of fascia lata of the tibia and also under the patella. Bandage removed on the eleventh day. Wound clean. Dog died on the sixteenth day.

Necropsy. Incision in the capsule well healed Flap beneath patella partly broken down. On opening through the line of the joint, the flap is found to be alive about the periphery and in the intercondylar region forming a rim of tissue about and attached to the tuberosities of the tibia simulating semilunar cartilages. The flap is also attached to the capsule about the condyles of the femur. The intercondylar portion of the flap is loosely adherent both to the tibia and femur. In each condylar region it is entirely broken down, leaving 2 perforations the lateral of which is the larger (Fig. 16). Mesially the bony surfaces of both tibia and femur come in contact and are somewhat polished from friction; on the lateral side they are covered by débris from the necrotic flap. The *patella* is covered by a thin layer of partially necrotic flap. The surface of the *femur* opposite the patella is covered by a fibrous ingrowth apparently from the sides (perhaps from the marrow spaces). The patella and quadriceps tendon are, loosely adherent to the femur.

Microscopic examination. Femur. Transverse section of the femur beneath the patella. The surface is covered by a newly formed fibrous layer and by a portion of the patellar flap which is adherent to the surface about the middle. The bony surface is smooth and spongy, with numerous newly formed trabeculæ. There is slight fibrosis of the superficial marrow spaces.

Transverse section through the *condyles of the femur.* The condylar surface is smooth and formed by spongy bone which in places is covered by a layer consisting of fibrin in its outer portion, fibroblasts, and new connective tissue along the bony surface. This fibrous covering is growing out from the marrow spaces and absorbing the fibrinous outer layer. In places where the bony surface is bare, there is marked cortical new bone formation. The fibrous marrow extends deeply into the underlying bone.

Fig. 29. Free flap. 129-day experiment. Dog No. 23. Adhesion *A*, with synovial covering arising from intercondylar groove *B*.

A transverse section through the *patella* shows articular cartilage all removed except about the mesial margin. The surface is formed by spongy bone. There is a thin bridge of flap over the articular surface which becomes thicker at either side. There is considerable necrosis of the flap overlying the articular surface. A thin layer of fibroblasts attach it to the patella.

The patella flap is thinned out and partly visible. The joint surface was between the flap covering the tibia and the femur. The articular surface is forming on the femur by sclerosis of the bare portions subject to pressure and fibrous overgrowth of the remaining portions. The fact that the flap was more extensively broken down in its lateral portion near the pedicle shows that pressure is responsible for the necrosis and that the distal portion of the flap does not get its nutrition through the pedicle.

42-day experiment. Dog No. 78. Knee-joint. Extensive bone resection. Patella left intact. Pedunculated flap of fascia and muscle interposed between femur and tibia. Bandage changed on fifth day. Mild skin infection which cleared up in a few days. Dog died on forty-second day.

Necropsy. Flail joint. There is a posterior subluxation of the tibia. Remnants of the condyles of the femur are saddled over the anterior

prominent part of the tibial crest and bulge forward in contact with the tibiopatellar tendon. Marked erosion of the internal condyle and deepening of the intercondylar groove. Patellar articular surface of the femur is adherent to the tibiopatellar tendon and its lateral ligament, obliterating the upper recessus of the joint. On cutting through the joint capsule, a cavity is found between the condyles above, and the anterior tibial surface and the tibiopatellar tendon below and in front. The fascial flap is seen distinctly covering the entire surface of the tibia and reflected upward over the posterior surface of the patellar tendon to the upper limit of the joint cavity. It is partly eroded transversely just behind the insertion of the tibiopatellar tendon where compressed between the opposing surfaces of the femur and tibia. Posteriorly there is a second cavity separated from the joint space by a transverse curtain attached to the posterior limit of the articular surface of the femur. The external condyle of the femur is rough and bare but not dense. The internal condyle is covered by fresh reddish granulations. The ends of the flap are well preserved and fused with the capsule on either side.

The flap is preserved in four-fifths of its extent and at either side because the femoral condyles are extensively resected and displaced forward, and there was no pressure on the intact portion. The flap apparently played no part in the joint formation.

Microscopic examination. A transverse section through the anterior surface of the *femur* shows a thin fibrous covering over the spongy bone, which is an outgrowth from the surface and has no connection with the flap (Fig. 17).

A transverse section through the articulating part of the *femoral condyles* shows the surface of the external condyle formed by bare, somewhat roughened and spongy bone with particles of eroded trabeculæ and buds of the outgrowing granulations in the cortical marrow spaces. At the external margin is a small exostosis. The rest of the articular surface is covered by a fibrous layer which is thick over the intercondylar groove and thin over the mesial condyle. There is some cortical sclerosis and superficial fibrous marrow. The surface of the fibrous covering is made up in its thicker portions of granulating necrotic tissue, in its thinner portions of denser fibrous tissue running parallel to the bone.

A transverse section through the middle of the upper end of the *tibia* back of the weight-bearing area is completely covered by the fascia lata flap which is alive and adherent to the bony surface by richly cellular, fibrous tissue, growing out from the marrow spaces (Fig. 18). The bony surface is regular and shows no new bone formations. The tips of some of the trabeculæ are undergoing lacunar absorption. There is an extensive exostosis at either side. The flap shows some evidence of necrosis in its middle half, but is revascularized and richly cellular along its bony attachment and its free surface which evidently lay outside the joint and was attached to the surrounding tissues, as there is no evidence of joint lining.

This is the most pronounced instance of preservation of flap but the reasons for it are obvious. The bones were extensively resected and the tibia backwardly subluxated so that the flap was compressed between the bony ends in only a small portion of its extent, in which region breaking down occurred.

56-day experiment. Dog No. 4. Elbow. Triceps tendon cut. Articular cartilage removed with a chisel. Pedunculated fascia and muscle flap sutured over the radius and ulna. Dressing removed on the twelfth day. Wound clean. At the end of 56 days the limb is little used in walking. Range of motion about 60 degrees. Animal sacrificed.

Necropsy. Triceps tendon completely healed. No evidence of infection. Capsule entirely restored. The joint surfaces are adherent at the top of the olecranon and in two places along the intercondylar groove. The end of the head of the *radius* is smooth and bare over the central portion. The marginal surface is irregularly destroyed and replaced by a layer of granulation tissue which has eaten away the bony cortex except in two small islands over either condyle where the surface is dense, shiny and bare. The bony articular surface of the *ulna* has all been eaten away and covered by a layer of fibrous granulation tissue except over a narrow dense area along the crest and a larger dense sclerotic area which was directly opposite and in contact with the smooth internal condyle of the humerus.

Microscopic examination. A transverse section through the articular surface of the *ulna* shows a thin fibrous covering of the entire articular surface. It is closely adherent to the bone and is slightly necrotic along the joint surface. A bony exostosis is present at either side.

Humerus. Transverse section through middle of condyles of humerus shows a very irregular surface covered by a layer of fibrous tissue varying in thickness throughout its entire extent. The cells and fibers of this covering are dense and run parallel to the bony surface. It is reflected over the margins of the condyles on to their sides. The underlying bony surface is spongy and devoid of a cortical layer. The marrow spaces extend up to the fibrous covering and are filled by a loose fibrous vacuolated tissue which is not intimately connected with the covering. A few newly formed cortical trabeculæ are seen. There is a sharp bony projection at either margin which is undergoing lacunar absorption and about which there is also some new

bone formation. The free surface of the fibrous covering is in places necrotic. A cut surface of an adhesion is seen near the external condyle.

Ulna. Transverse section through post part of ulnar articular surface shows the surface covered in its entire extent by a layer of fibrous tissue which runs parallel to the bony surface. It is thin along the crest and increases in thickness toward the sides where there are bony exostoses. The bony cortex is dense, but somewhat worm-eaten along the surface beneath the fibrous covering. The joint surface extends beyond the exostosis at either side, where there is a villous arthritis and over the mesial exostosis, a tendency to differentiation of the lining into fibrocartilage. There is no endothelial lining, the surface being mostly irregular and necrotic. No section was made through the dense bare bony region.

The fibrous ulnar covering appears to have grown in from the sides and out from the ends of the bone. It is thinnest over the ulnar crest where subject to the greatest pressure. In places it consists of dense, flattened fibrous tissue, in one place showing a tendency to form fibrocartilage. The covering of the humeral articular surface resembles in some respects a persistent flap, but there is nothing about its histological structure which identifies it definitely as such.

76-day experiment. Dog No. 1. Elbow. Lateral incision. Triceps tendon cut and sutured after removal of the articular cartilage with a chisel. Pedunculated flap used. Wound healed rapidly, though infected; bandage left off on twelfth day. Joint not used in walking. Animal died on seventy-sixth day. Limb held in flexion. Range of motion about 15 degrees.

Necropsy. Fibrous ankylosis. Articular surfaces joined by fibrous adhesions. Cavity practically obliterated except for a few small pockets anteriorly. When separated there is a thick fibrous covering over the articular surface of each bone. Head of the *radius* (ulnar side) bare over a small area. In region of the three small pockets anteriorly the bony surface is practically bare.

Microscopic examination. Humerus. Transverse section through condyles. Posterior portion shows thick fibrous covering with areas of degeneration along the surface. Small cavities with necrotic walls representing small joint pockets. About the intercondylar groove is a larger cavity which opens onto the surface. The character of the fibrous covering varies according to the thickness and whether it is a continuation of an adhesion. In the latter case, its free margin is a cut surface and it is fairly rich in nuclei and blood-vessels. The cells and vessels are arranged in columns radiating from the bony surface and are more numerous in the deeper portions next to the bone. There is a somewhat irregular, frail, newly formed bony cortex. The marrow spaces extend irregularly out to the surface and are filled with bone marrow, little fibrous marrow being present. This is in marked contrast to the earlier specimens showing fibrous marrow.

Normally as the joint surface becomes reformed the cortical fibrous marrow which forms early, recedes, giving way to normal marrow.

Slow ossification of the fibrous bridge is proceeding from the bony surface by enchondral bone formation. This gives the junction of the bone and covering the appearance of an epiphyseal line. It seems probable that a bony ankylosis would eventually have been established.

92-day experiment. Dog No. 35. Knee. Tibiopatellar tendon cut. Articular cartilage and some underlying bone removed with chisel. Pedunculated flap of fascia lata interposed between femur and tibia. Dressings removed on seventh day. Wound clean. On thirtieth day flexion complete, extension to 145 degrees. On ninty-second day flexion complete, extension to 145 degrees. Limb not used in walking. Joint flail.

Necropsy. ***Patella*** movable but is attached by loose fibrous adhesions between which are small cavities. Its surfaces and the opposing surface of the *femur* are partly bare, partly covered by adhesions. Upper recessus of the joint obliterated. Tibiopatellar tendon lengthened and represented by a thin fibrous band. On opening the joint there are 2 cavities, a larger mesial and a smaller lateral one, separated by an anteroposterior partition extending from the crest of the tibia to the lateral side of the intercondylar groove. The limb is held in flexion and the posterior portion of the condyles border on these joint cavities, the anterior inferior portion being extracapsular and covered by fibrous tissue. The bony surfaces of both cavities are irregularly grooved, dense, and almost entirely covered by fibrous tissue. The mesial cavity contains fibrous tags and fibrinous flocculi resembling villous arthritis.

These joint cavities are comparatively small and are formed with the limb in flexion; despite this there is a wide range of motion.

Microscopic examination. Femur. Transverse section through prominent portions of condyles of femur shows an irregular bony surface covered largely by a thin fibrous outgrowth which is necrotic along the surface. There is a small surface of bare dense bone at the outer margin of the external condyle and about the middle of the internal condyle.

Tibia. Through points of contact. Joint cavity extends laterally beyond the bony limit into a recessus with a villous necrotic lining. The flap is broken down over the lateral bony margin and bare, dense bone forms the joint surface. Over the depressed external tuberosity remnants of the flap are adherent to the underlying spongy, bony surface with extremely irregular villous necrotic surface lining the joint cavity laterally. Mesially there is a smooth joint surface and the cut surface of a broad band which crosses to the femur to form a partition. The mesial joint cavity extends from the lateral surface of the tibial spine to the inner limit of the bony surface. Mesial tuberosity markedly depressed. The tibial spine in the middle is bare, dense, and polished. There is an irregular thick remnant of flap covering the entire tuberosity and attached to the internal capsule of the joint. On its upper side the flap forms the lining of the joint cavity which is villous and necrotic along the border. Along its lower surface the flap is adherent to the lateral portion of the internal tuberosity at the base of the tibial spine, but separated from the mesial surface of the tuberosity by a flattened cavity, the walls of which are formed by the flap above and a fibrous outgrowth from the tibial surface below, and which is continuous internally with the mesial recessus of the joint beneath the flap. This recessus has a synovial lining, but the joint cavity over the tuberosities where subject to pressure has a necrotic lining. The cortical bone over the depressed regions is porous and shows lacunar absorption.

Two main joint cavities are formed between the femoral surfaces above and the flap below, but the flap is broken down over the tibial spine and outer margin of the external tuberosity where dense bone forms the joint surface. Mesially where the flap is thick a narrow cavity is formed between it and the fibrous covering of the surface of the tuberosity. This cavity communicates with the mesial joint recessus. This is not the true joint cavity but a sort of bursal sac between the flap and tuberosity, where there was little pressure. It was by this method that Sumita and Payr thought that the new joint cavity was formed.

125-day experiment. Dog No. 74. Knee. Extensive section. Patella not disturbed. Pedunculated flap used. Wound infected. Dressings left off on twelfth day. Wound healed in 2 weeks. Range of motion 35 degrees.

Necropsy. Joint capsule markedly thickened. Exostosis about the bony margins. There is a cavity beneath the patella continuous with a large tibiofemoral joint cavity. The tibial surface is somewhat cup shaped. Most of the joint surface of both bones is formed by eburnated, polished bone. It is impossible to identify any remnants of flap. The irregular depressed areas between the regions of eburnated bone are covered by fibrous tissue. The margins of the dense portions are covered by a thin fibrous layer which is apparently growing in from the sides in an endeavor to cover all raw bony surfaces. There are large tags and irregular projections from the capsule as in a villous arthritis. There is extensive ossification in the thickened capsule at its points of attachment to femur and tibia.

Microscopic examination. Femur. Transverse section through anterior surface of femur just above patella. Complete obliteration of the upper recessus. The bony surface is smooth and spongy, with a few newly formed trabeculæ and some evidence of superficial absorption. It is covered by a layer of fibrous tissue which is dense and arranged parallel to the bony surface in its deeper portions, but loose and irregular superficially.

Femur. Transverse section through middle of condyles within joint cavity. The capsule is thickened on either side and exostoses extend outward into it. There is a villous synovial lining to capsule on either side. The articular surface is fairly regular. It is interrupted by six small grooves. The articular surface consists of bare, dense, polished bone over most of the surface of the broad intercondylar groove and the mesial half of the internal condyle. The lateral half of the mesial condyle and nearly all of the external condyle are covered by a dense fibrous tissue which, with the bony surface, is irregular and grooved. In places the fibrous covering is differentiated into a fibrocartilage with ossification proceeding into it from the bony surface, resembling articular cartilage. The grooves are being filled with bone by ossification proceeding from the sides. There is a little tendency toward a fibrous overgrowth of the bare bony surfaces about their margins. Joint lining formed largely by dense fibrous tissue poor in nuclei. Where it covers a bony articular surface, frequently it is necrotic, villous, and shows a tendency to metaplasia into fibrocartilage.

Despite the extreme thickening and ossification of the capsule which were augmented by the infection, there was joint cavity formation. The lining is largely fibrous and villous. There are still areas with a bare, bony surface and little evidence of active replacement by fibrous tissue about their margins. A cavity exists beneath the patella which is due no doubt to the fact that its articular cartilage was not removed.

146-day experiment. Dog No. 66. Knee-joint. Extensive resection. Pedunculated flap of fascia lata interposed between femur and tibia — also

under the patella. Bandage left off on seventh day. One hundred and forty-sixth day limb used slightly in walking. Extension to 150 degrees; flexion complete. Joint somewhat flail. Animal killed. Slight backward dislocation of the tibia. Patella movable.

Necropsy. The excised joint has good mobility with some upward and downward movement of the patella. The joint is multilocular. There are four cavities, two anteriorly beneath the patella and upper part of the tibiopatellar tendon, and two between either condyle and the opposing tuberosities. The partition between the latter is in the region of the crucial ligaments. It is impossible to identify remnants of the flap as such. The surface of the *patella* is markedly eroded in its upper portion, eburnated, and polished inferointernally. The articular surfaces of the *femur* and *tibia* are irregular and covered by a fibrous layer except at points of contact of the condyles and tuberosities, where the bony surfaces are either bare or covered by a thin overgrowth, or outgrowth, of fibrous tissue. The small bare area over the lateral tuberosity of the tibia is eburnated and polished. There is a depression in the opposing portion of the external femoral condyle.

Microscopic examination. Femur. Transverse section anteriorly through lower part of patellar articular surface of femur. Articular surface over lateral condyle and intercondylar groove formed by smooth spongy bone with evidence of absorption of the ends of the trabeculæ and a little new bone formation. The lateral limit of the mesial condyle is prominent, sclerotic, and bare. Just mesial to this, there is a deep groove at the edge of which is a bony exostosis. The groove is covered by a thin fibrous layer which partly fills out the defect and forms an irregular necrotic joint surface. A mesial joint recessus is lined by endothelium. The intercondylar groove is filled with a thick layer of fibrous tissue which forms the joint lining mesially and presents a cut surface of an adhesion laterally. This layer is continued over the external condyle, becoming very thin at its lateral margin. There is a joint cavity with a superficially necrotic lining over the entire surface of the lateral condyle.

Tibia. Transverse section through tibial articular surface shows a marked exostosis at either edge, especially laterally. Covering the joint surface and the exostosis is an irregular, thick, fibrous layer, along the free surface of which there are cavities both mesially and laterally, separated by broad fibrous bands. At either edge and extending out over the exostoses there is a slit-like cavity between the flap and the bony surface which does not communicate with the joint cavity. The lining of a part of the cavity resembles endothelium; the rest is necrotic and irregular. It contains some small fibrinous masses (Fig. 19). The bony surface of the joint is very irregular, over the lateral portion of either tuberosity being quite dense, elsewhere only moderately sclerosed. The ends of the bordering trabeculæ show lacunar absorption. The fibers of the covering run irregularly parallel to the surface except where the adhesions radiate out from the surface.

Patella. Transverse section. The articular cartilage is all removed. The mesial surface is of bare, dense bone. The base of the flap at the edge which has broken down is represented by small villous tags. The lateral surface is covered by a thin fibrous layer which has a tendency to differentiation into endothelium along the surface. There is a thick overhanging ledge of fibrous tissue extending inward from the side to middle of the patella. It has a villous necrotic surface and may represent the lateral remnant of flap, but is separated from the bone by a joint space.

The cavity between the surviving portion of the flap and the tibial margin resembles to some extent a bursa and may correspond to what Sumita took for bursa-like formation within the flap. It no doubt arose from the play of the flap over the bony margin produced by the constant motion in the joint but forms no part of the true joint cavity.

161-day experiment. Dog No. 3. Elbow. Articular cartilage removed except small amount on side of external condyle. Superficial bony surface partly removed. Pedunculated fascial flap interposed. Dressings left off on ninth day. Wound clean. Mobility remained free throughout and at the date of sacrifice was almost normal in extent. The limb was used to some extent.

Necropsy. Upon opening the capsule a joint cavity free from adhesions along the bony surface is found (Fig. 20). The flap has disappeared except a portion of the pedicle which was adherent to the outer portion of the ulnar articular surface and is white and very dense. There is a villous arthritis of the synovial membrane on the mesial side of the joint. The articular surface of the humerus is dense, smooth, shiny, and free from cartilage except for small islands about the periphery which have re-formed. In these areas the bony surface is slightly depressed as if previously eroded by overgrowing tissue. A similar condition is found on the ulnar articular surface. There is a defect on the mesial side of the ulnar ridge due to erosion which is filled out with fibrous tissue. A fibrous disc representing the base of the flap is firmly adherent to the lateral side of the ulna and posterior portion of the radial head. The surface of the radial head is partly covered by apparent islands of cartilage. The rest is formed by dense polished bone.

Microscopic examination. A section transversely through middle of *femoral condyles* has a smooth free articular surface throughout. At either side the attached capsule shows villous arthritis. A bony exostosis projects from the lateral margin. The

entire surface of the internal condyle is of smooth, dense, bare bone (Fig. 21). The cortical trabeculæ are increased in number and are arranged at right angles to the surface. A small amount of superficial necrosis is seen, the lacunæ of the trabeculæ along the border being empty. The marrow spaces are greatly diminished in size and some of them extend out on to the bony surface. Most of them are filled superficially with a necrotic débris some of which takes a heavy blue stain indicative of calcification. There is no fibrous marrow in this region. In the intercondylar groove and extending a short distance onto the lateral condyle the bony surface is thick and covered by a thick layer of imperfectly formed articular cartilage which thins out at either side. Its cells are arranged in very irregular columns. The intercellular substance is hyaline along the periphery and calcified along the bony surface (Fig. 22). There are no active signs of a fibrous overgrowth about the margins of the bare, bony areas. The external condyle is covered by a strip of articular cartilage which is very thin mesially but gradually increases in thickness as the lateral margin is reached until it surpasses the normal thickness at the edge where it covers the osteophyte formed at the side. In places it shows degeneration down to the bone. It rests upon a bony cortex which has a normal appearance and the deeper portion of the cartilage is calcified, lamellated, and has cells radiating in columns from the bony surface as in a normal joint (Fig. 23). The underlying marrow appears normal. At the junction of the cartilaginous covering of the intercondylar region and the external condyle there is, just beneath the surface, a fibrous round mass which is undergoing ossification. This is possibly the remnant of a groove that is being filled out. A wedge of fibrous tissue resembling the pedicle of the flap extends inward from the capsule at the outer margin of the external condyle. Sections of the covering over the ulnar articular surface show laterally a villous arthritis. It is difficult to say whether or not it represents the remnant of flap.

This is the best reconstruction of the entire series of experiments. Mobility was free and the joint cavity almost normal in extent. The articular surface was formed by dense, polished bone over the internal condyle, but by a layer of articular cartilage in various stages of development over most of the remaining portions. In some places the restoration was so complete that it could hardly be distinguished from normal articular cartilage, all of which it was thought was removed at operation. If any cartilage was left it was in the shape of small islands which would have had to possess an unusual degree of proliferation to give rise to this extensive covering. The flap had all disappeared except a small portion of the pedicle.

RÉSUMÉ OF CHANGES FOLLOWING IN PEDUNCULATED FLAP OPERATIONS

Summarizing, it will be seen that in the well constructed and fitting joint, the flap undergoes necrosis at the points where it is subjected to any degree of pressure between the ends of the bones. The flap breaks down first over the central portion at the points of greatest prominence of the condyles and tuberosities. In case of the knee-joint, two holes appear in the flap over either tuberosity of the tibia by the fifth to the sixth day. In Fig. 16, Dog 82, 16-day experiment, the greater necrosis is over the external tuberosity which is nearest the pedicle of the flap. This shows that little nutrition reached the flap through the pedicle and that pressure was the cause of the necrosis. The perforations are separated by a bridge running anteroposteriorly along the intercondylar groove which is little subjected to pressure. As time goes on, more and more of the flap becomes necrotic until finally nothing is left of it except perhaps a rim about the margins of the joint, or an irregular strip lying in a groove where it has not been subjected to pressure. The peripheral portion of the flap becomes attached to the surrounding synovia or capsule and survives. In the earlier experiments on the knee-joint, going from the periphery toward the central portions of the condyles, the flap thins out, becomes necrotic, and disappears, leaving a margin about the periphery closely resembling the semilunar cartilages. This is also seen in portions of the elbow-joint as illustrated by the 9-day experiment No. 5, Fig. 13, but persisting bridges extending across the joint along the intercondylar groove of the humerus were not observed as was the case occasionally with the knee. Where resection was extensive or dislocation occurred thereby diminishing or completely removing the pressure upon the flap greater areas survived. In this event the somewhat altered remnant of flap usually became attached to the end of the bone over which it had been sutured, i.e.,

tibia in case of the knee, and humerus in case of the elbow, and the joint cavity formed between its free surface and the opposing bone or the flap came to lie outside the joint cavity which was much diminished in size (see No. 78 42-day experiment). In no instance was the flap seen to split and become attached to the ends of the two bones, thus forming a joint cavity within its substance as suggested by Murphy and Payr, and described by Sumita.

The formation of small cavities was observed between a portion of the surviving flap and the margin of the bone to which it became adherent but lying outside the newly formed joint (Fig. 19). These correspond closely to what Sumita described as cavities formed within the flap.

The changes in the ends of the bones over which the flap broke down are identical with those in the no-flap operations. The areas subjected to pressure undergo sclerosis forming a hard, smooth, polished joint surface, while those subjected to less pressure acquire a fibrous covering. The tendency of the fibrous covering to change into articular cartilage increases with age. These points are especially well illustrated by experiment No. 3, 161 days, Figs. 21–23.

Flaps placed beneath the patella behaved in the same way breaking down in their central portions but remaining alive about the periphery of the patella and beyond the zone of pressure where they became adherent to the surrounding capsule. Cavity formation beneath the patella occurred oftener when its articular cartilage was left intact and no flap was inserted.

The size of the joint cavity and the amount of villous arthritis in the older experiments were about the same as they were in the no-flap series.

It is difficult to understand how anyone who has worked much with pedunculated flaps can believe that any appreciable amount of nutrition is furnished by the circulation through the pedicle. All of the evidence in these experiments spoke for the re-establishment of circulation in the surviving portions through adhesions to the parts with which they came in contact.

FREE FLAP EXPERIMENTS

The difficulty of securing a pedunculated flap of the proper size and thickness in certain instances and locations led to the use of the free flap. Murphy stated that he used this method on the human in two of his earlier cases with poor results, but little experimental work was done for determining its rôle in the process of new joint formation.

Kirschner in his extensive review of fascia transplantation cites a number of instances of its clinical use in the mobilization of ankylosed joints but presents no evidence as to how it acts, simply stating that it is as good as any other material for the purpose.

Allison and Brooks who made careful studies of experiments in which the flap was placed in the joint space between the patella and femur, found that it rapidly broke down and was removed from the joint. The same changes were noted in the ends of the bones as where pedunculated flaps were used, but again no experiments were performed upon the joint between the tibia and femur.

Nineteen experiments were studied, 10 of which were on the elbow and 9 on the knee. Six experiments were mildly infected, all of which healed promptly.

2-day experiment. Dog No. 41. Knee. Tibiopatellar tendon cut. Resection made with a saw and chisel. Free flap of fascia lata between femur and tibia. Dog died on second day. Wound clean.

Necropsy. No evidence of infection. Tibiopatellar tendon had separated. The capsule had begun to unite on both sides. The base of the flap (which had been cut free) was partly united to the capsule. The entire surface of the *tibia* is covered by the free flap which toward the joint side is covered by a serofibrinosanguineous exudate. The articular surface of the *patella* and tibia is covered by the same kind of exudate.

Microscopic examination. Femur. Anteroposterior section through mesial condyle. Bony surface fairly regular. Articular cartilage and underlying cortical bone removed, leaving a cancellous bony surface. Numerous fragments of sawdust in open marrow spaces. Irregular thin covering of hæmorrhagic exudate. Little change in underlying marrow; in a few places it shows blood extravasation; in others beginning connective tissue proliferation. Section of the flap shows beginning necrosis in the center, leucocytic infiltration about the periphery.

Flap. Periphery of flap alive. Slight fibrous proliferation. Central portion slightly compressed. Leucocytic infiltration and evidences of necrosis.

5-day experiment. Dog No. 50. Knee. Extensive resection. Free flaps of fascia lata between tibia and femur and under patella. Wound clean at end of 5 days. Animal sacrificed.

Necropsy. Line of incision in capsule open except for a narrow tibiopatellar band to the right of the midline. No evidence of any infection but considerable old blood had collected in the area from which the flap was taken. On laying the joint open (the patella had been dislocated to the right) necrotic fragments of flap are seen over greater portion of tibial surface. Portions of the flap protruding beyond the tibial surface and adherent to the capsule appear alive. Patellar flap partly alive and adherent about edges. Condylar surfaces of femur bare. External condyle markedly grooved from erosion by protruding upper end of fibula. Intercondylar surface and sides of condyles covered by granulations. Upon removal of the granulations a shallow depression is left, the floor of which is rough, spongy, and red as contrasted with the pale, dense, surrounding surface.

Microscopic examination. The flap covering the patella shows considerable necrosis. Granulations are beginning to invade it from the underlying patellar surface which shows slightly fibrous marrow near the surface. Posterior part of flap between tibia and femur shows considerable necrosis and œdema. Many cells in the dense fibrous region are alive and an uncompressed region shows proliferation of cells along both surfaces (Fig. 24). The vascular spaces seem filled with exudate. There is marked hypertrophy along the bony surface. The tibial surface is covered by a layer of granulations with overlying fibrinous exudate. Flap not adherent to the bone. Superficial marrow slightly fibrous.

There was mesial displacement of the tibia and fibula and extensive erosion of the lateral condyle by the prominent and pointed upper end of the fibula. Flap necrosis is well under way where compressed but shows marginal proliferation where free from pressure.

6-day experiment. Dog No. 59. Elbow. Extensive resection. Free fascia lata flap used. Death on sixth day. Skin wound clean but on removal of the soft parts an abscess was found anteriorly in the muscles communicating with the joint.

Necropsy. Joint capsule partly open. Large abscess anteromesially in the flexor muscles connected with the joint. Capsule and surrounding muscle inflamed. All of transplant broken down except a band posteriorly extending across the joint, covering the posterior part of the internal condyle, intercondylar groove and part of the external condyle. Bony surfaces smooth and show little evidence of erosion.

Microscopic section shows the flap very necrotic especially in the deeper portions where practically all the nuclei have disappeared. Superficial portions at one end show extensive leucocytic infiltration and granulations. At other end in the region of dense, fibrous tissue, slight leucocytic infiltration and occasional connective-tissue nuclei are seen.

The results of the infection are shown in the rapid breaking down and removal of the flap and in the bare, bony, articular surfaces.

7-day experiment. Dog No. 24. Elbow. Resection with chisel. Free fascial flap used. Extensive infection. Death on seventh day.

Necropsy. Joint opened through capsular incision. All traces of transplant disappeared. Entire ends of bones bare and shiny.

Microscopic examination. Humerus. Articular cartilage all removed but underlying bony surface not removed in most of its extent. In places the superficial bony covering was removed but not as deep as the underlying marrow spaces except at one point anteriorly where there is marked fibrous marrow rich in capillaries. Extending forward from the anterior recessus of the joint is a tongue-shaped narrow flap between the bony surface and the old capsule about ⅔ of a cubic centimeters long which resembles the margin of the flap which did not break down. There is an outgrowth of granulation tissue but no definite evidence of its being a flap. Capsule shows acute inflammation. The bare, bony surface is due to the death of the surface of the bone from the infection which has as yet prevented the outgrowth of granulations from the hyperæmic underlying marrow.

Infection has produced bare bony surfaces and complete disappearance of the flap.

14-day experiment. Dog No. 44. Knee-joint. Tibiopatellar tendon cut. Ends of tibia and femur removed with a saw. Free flap of fascia lata inserted. Animal killed on fourteenth day. Wound clean.

Necropsy. Incision in joint capsule entirely closed. Tibiopatellar tendon apparently healed. Patella adherent to the femur by granulations. Upper recessus obliterated. Joint cavity present in condylar region. The flap is necrotic over area in contact with the condyles. Central portion completely destroyed allowing contact of bony surfaces. Peripheral portions of the flap are shaped like semilunar cartilages and are partly alive. The flap over the tibial crest is necrotic in its central portion where there was pressure. Condylar surfaces are bare and grooved anteroposteriorly the mesial one more so, from erosions by tibial surface. The margins, intercondylar groove, and anterior surface in contact with the patella are covered by granulations which are eroding the dense bony surface. The surface of the patella is also covered by granulations.

Microscopic examination. Tibia. Transverse section. Nothing present that can be definitely iden-

tified as a flap except about margins. Marked deepening of the condylar groove at either side of tibiael crest. The epiphysis is so extensively removed laterally that only a thin bridge forms the external tuberosity. Below this there is extensive periosteal new bone formation which extends downward along the mesial side of the shaft for a distance of 1 cubic centimeter. At the upper limit of the shaft just beneath the joint surface is a large island of cartilage resembling a center of ossification. The articular surface in the region of the tuberosities is covered by a layer of granulation tissue which thins out and disappears over the intercondylar ridge. Mesially it blends with the capsule and laterally thins out over the projecting ledge of bone forming the external condyle where it disappears. This covering consists of fibroblasts with large vascular spaces in its deeper portion and an extremely irregular necrotic surface. The vessels run from the bone toward the periphery. Underlying bony surface is irregular. In region of tibial crest where dense bone was left the surface is bare, sclerotic, smooth and slightly grooved. Marked new bone formation in underlying trabeculæ to a depth of ½ cubic centimeter (Fig. 25). Slight new bone formation along surface of the depression in mesial tuberosity. Sclerosis more marked at the side where it came in contact with underlying island of cartilage. Moderate sclerosis of the cortex of the shallow groove on the external tuberosity. Marked sclerosis of the ledge of bone forming the lateral part of external tuberosity. The surface of the lateral tuberosity which is devoid of covering is polished with bony débris in the superficial marrow spaces. Periosteal new bone formation along the lateral surface of the shaft and ledge is by enchondral ossification; that in the articular end is by fibrous ossification.

Marked sclerosis along the bare cortex has occurred at points of contact and weight bearing, less so in the depressed areas. Compensatory hypertrophy has resulted to support the weakened ledge forming the external tuberosity.

Femur. Transverse section through condyles. Condylar surfaces are bare and eroded, bone dust filling in the crevices along the surface. Marked cortical new bone formation. Over the groove where there was no pressure a necrotic exudate is seen, bony cells, spongy and marrow spaces slightly fibrous.

15-day experiment. Dog No. 68. Knee. Extensive resection. Free fascia lata flap used between tibia and femur. Fascia and muscle flap from vastus internus beneath patella. Dog died on fifteenth day. Wound clean.

Necropsy. Posterior subluxation of tibia. Patella movable on femur. New capsule completely formed. Condyles of femur rest against the anterior margin of the tibia down to the tibial tuberosity, pushing forward the tibiopatellar tendon. The quadriceps tendon, patella, and capsule on either side are adherent to the inferior and anterior articular surface of the femur. The flap covering the upper end of the tibia is intact and adherent to the tibia except anteriorly where it was pressed upon by the condyles and has disappeared. The posterior capsule of the joint is stretched forward over the upper end of the tibia by the dislocations and is loosely adherent to the flap which is very thin. It fuses about the margins with the capsule. In its necrotic portion it is free and easily dissected from the tibia. The posterior part of the condyles at points of contact, show extensive pressure necrosis. The surface about the margins of this area which are within the cavity are covered by granulations. Joint cavity very small. Flap beneath patella broken down over its lower portion, but forms a thin layer over the upper portion and about the margins.

Microscopic examination. Tibia. Transverse section through region not subjected to pressure shows articular surface removed almost to the epiphyseal line. There is a central elevation corresponding to the tibial spine. Bony surface is spongy with necrosis of some of the ends of the trabeculæ. The superficial marrow is fibrous. There is practically no cortical new bone formation. The surface of the mesial tuberosity is covered by a thin layer of granulations which run irregularly parallel to the surface and have grown out from the marrow spaces. Lateral surface is covered by thinned out remnant of flap which shows moderate necrosis. The flap is adherent to the underlying bone by newly formed fibrous elements. Necrosis in the flap is more marked along the joint side than along the bony surface. There is some revascularization and proliferation of the surviving fibrous elements (Fig. 26).

Tibia. Transverse section through anterior part where the flap is adherent to the capsule at the side of the tibiopatellar tendon. Flap folded and considerably degenerated. There are recesses and small cavities in it with necrotic walls. Some revascularization and proliferation of the surviving connective tissue cells is seen.

Where the flap was subjected to pressure it underwent necrosis as over the tibia and the patella. Where there is no pressure and no flap a fibrous covering has formed as on the anterior surface of the femoral condyles.

17-day experiment. Dog No. 30. Elbow. Resection with chisel. Free fascia lata flap. Wound badly infected. Death on seventeenth day.

Necropsy. Joint wide open laterally. Capsule thickened and inflamed. Articular surfaces are bare. Some granulation tissue from capsule filling marginal recesses of the joint.

Microscopic examination. Humerus. Transverse section through condyles. Bony surface bare in most

of its extent. All of the tissues stain poorly. There is a capsular overgrowth for a short distance along the inner surface of the internal condyle, in which are fragments of cortical bone which were detached but not removed at operation. The rest of the surface of the mesial condyle is bare and fairly even. The marrow spaces are open. There has been no cortical new bone formation and the exposed trabeculæ have been powdered by friction and the fragments fill the intertrabecular spaces along the surface. The superficial marrow is slightly fibrous and surrounds the small surface fragments. The cells stain very poorly and the tissue appears somewhat œdematous, degenerated, and necrotic. The intercondylar groove is covered by a necrotic fibrous layer which may be a remnant of the flap. Along the bony surface more of its cells are living and arranged parallel to the bone. No cortical sclerosis and very little underlying fibrous marrow. The mesial portion of the lateral condyle is bare and covered by considerable powdered bone. Here there is some cortical sclerosis and more underlying fibrous marrow. The outer surface of the condyle shows absorption of the bony trabeculæ and a fibrous covering continuous with the underlying fibrous marrow. Bone absorption is seen along the surface and at the side where the fibrous meets the sclerotic area. The deeper marrow and trabeculæ stain poorly in the whole section.

Despite the infection there is a tendency to formation of a fibrous covering, sclerosis of the portion of the cortex subject to pressure and little evidence of infection invading the deeper portions of the bone ends.

19-day experiment. Dog No. 83. Knee. Extensive resection. Free flap of fascia lata used over tibia and also beneath patella. Bandage removed on twelfth day. Wound apparently clean. Death on ninteenth day.

Necropsy. Capsule healed except for one small opening above the base of the flap. Patella quite adherent at margins to the capsule. Space between patella and femur filled with fibrin. Patella and ligament lay forward exposing two definite joint cavities between condyles and tuberosities separated by a partition of fibrinous adhesions joining the intercondylar groove with the tibial crest. A defect in the flap over each condylar region leaves the points of pressure bare, the marginal remnant of flap appearing like semilunar cartilages. There is definite evidence of mild infection in a large part of the joint which drained out through the small opening referred to above. The anterior surface of the *femur* is covered by a thin layer of fibrous tissue. The *patella* has a rough, bare central area surrounded by fibrous tissue.

Microscopic examination. Femur. Transverse section of anterior surface under patella. Covered by a thin layer of fibrous tissue with underlying spongy, slightly proliferating bone. The lateral bony margin covered by fibrin instead of fibrous tissue. This is apparently the point of contact with the patella.

Femur. Transverse section through condyles at points of pressure. Somewhat irregular articular surface. Marked thickening of the capsule and exostosis at sides of the joint. The mesial condylar surface is formed by spongy bone which is bare and somewhat necrotic in its middle portion with absorption of the superficial trabeculæ, slight depression of the surface and fibrous overgrowth on either side of the condyle. Intercondylar groove filled by irregular, very vascular fibrous tissue with a hæmorrhagic surface. External condylar surface irregular with definite evidence of inflammation in the cortical bone. The superficial bony trabeculæ are dead and the marrow spaces filled with leucocytes and granulations. There is marked absorption of this dead cortical bone by the surrounding granulations. The marrow spaces of the underlying living bone are not filled with newly formed fibrous tissue as in other cases of infection with cortical necrosis.

Tibia. Transverse section through anterior part of tibia including remnant of flap. Tibial surface narrow in this region with marked fibrous thickening and exostoses at either side. Flap extends across entire section but thins out and is necrotic leaving bare, bony surface in regions of tibial crest and a small area at outer margin of lateral tuberosity. The flap is moderately necrotic and slightly inflamed in thicker portions about margins and completely degenerated in its thinned out portions. There is necrosis of the cortical layer of bone with granulation tissue formation in its marrow spaces producing extensive lacunar absorption. The bare bone of the tibial crest is entirely necrotic and is being absorbed and separated by granulation tissue in its marrow spaces. In this region there is some new bone formation even in the presence of inflammation and extensive absorption.

The presence of infection has resulted in necrosis of the flap, and articular surfaces of the femur and tibia. Evidently such cortical necrosis leads to grooving and formation of adhesions. This experiment shows how an infection may extensively involve a joint and break through the capsule without involving the skin or giving external signs of its presence.

20-day experiment. Dog No. 88. Knee. Extensive resection of the joint. Patella left intact. Free flap of fascia lata used. Bandage removed on tenth day. Wound clean. Dog died on twentieth day.

Necropsy. Joint flail. Capsule entirely healed. Slight backward and upward dislocation of tibia. Tibiopatellar tendons and ligaments at either side adherent to the anterior surface of the condyles and articular surface of femur. Patella slightly movable above. On stripping down the tibio-

patellar tendon, a cavity is opened into in which the condyles and tibia are in contact. The flap is broken down in this region but intact about the margins where it forms a rim about the joint and is adherent to the newly formed capsule about the sides and tibiopatellar tendon in front. The external margin of the tibia fits into the intercondylar groove, and the tibial crest which was left at operation has been worn away by friction against the internal condyle. The surfaces of both are polished and are becoming dense. The other articular surfaces where there is no contact are rough and spongy. The posterior portion of the tibial articular surface where not in contact with the femur is covered by the adherent capsule.

Microscopic examination. Femur. Anterior surface below patella. The surface is covered by a thick fibrous layer which has undergone extensive necrosis. It is adherent to the spongy bone by a slight layer of fibroblasts which extends out from the marrow spaces. There is some absorption of the tips of the cortical trabeculæ. Slight new bone formation at margins. Similar changes are seen in the tibioarticular surface.

This joint shows the usual extensive degenerative changes and destruction of the interposed flap.

26-day experiment. Dog No. 81. Knee. Extensive resection. Free fascia lata flap used. Patella not disturbed. Bandage removed on twelfth day. Wound clean. Dog sacrificed on twenty-sixth day.

Necropsy. Limited motion. Limb held in flexion. The anterior part of the joint is obliterated. The tibiopatellar tendon and newly formed anterolateral part of the capsule are firmly adherent to the anterior surfaces of the epiphysis and condyles of the femur. A rather small joint cavity is found between the tibia and posterior portion of the condyles. It is difficult to trace the flap. It is apparently preserved about the margins and blended with the capsule. A band extends from the posterior part of the joint to the intercondylar groove. Bony surface of tibia bare and rough in central portion; a thin, dense, fibrous covering about the margins. Condyles of femur posteriorly rough and bare.

Microscopic examination. Femur. Transverse section through anterior surface above the joint. The surface is covered by a layer of fibrous tissue and the joint recessus is obliterated except for a small cavity at the mesial side which has a thick lateral wall and is partly filled with fibrinous masses. The cortical bone is spongy and shows no new bone formation. The epiphysis is not completely ossified and shows a rim of cartilage beneath the periosteum. There is a small amount of cortical fibrous marrow.

Femur. Transverse section through condyles in weight-bearing region. Considerable of the epiphyseal surface has been removed extending nearly to the epiphyseal line in the region of the intercondylar groove. The articular surface is quite irregular. The bony surface over the external condyle is porous and irregular and is covered by an incomplete fibrous and organizing fibrinous layer which seems to have grown out from the underlying fibrous marrow. In places the layer is very thin or absent but no corresponding cortical sclerosis is seen (apparently no pressure). The lateral surface of the internal condyle is composed of dense, bare, polished bone which is partly a remnant of the normal cortex and partly newly formed in the marrow spaces. The rest of the condyle has an irregular spongy, bony surface with slight new bone formation and a thick fibrous covering. The articular surface of the femur has an irregular necrotic lining where formed by fibrous layer. Where formed of bare bone there is little tendency to sclerosis.

Tibia. Transverse section through anterior portion. Epiphysis not entirely ossified. It was removed down to the epiphyseal line on the sides leaving a bony elevation in the region of the tibial spine. At the outer side there is a thick fibrous covering which probably represents remnants of the flap. Between this and the central bony elevation the epiphyseal line is covered by a thin layer of fibrous tissue running parallel to the surface, necrotic in its superficial portion. The most prominent part of the tibial spine has a dense bare bony surface with underlying fibrous marrow. The mesial tuberosity has a fibrous covering in its outer portion and a surface of unossified epiphyseal cartilage at its mesial border.

There are no flap remnants except possibly about the external tuberosity of the tibia. Irregular incomplete fibrous covering of the articular surfaces. Where joint surface is formed by bare bone there is little sclerosis. This can be attributed to the fact that there was extensive resection and little motion in the joint.

42-day experiment. Dog No. 22. Elbow-joint. Articular cartilage and some bony cortex removed with a chisel. Free fascial flap interposed. On fifth day cast removed. Slight skin infection at lower angle. On twelfth day wound healed. On forty-second day range of motion 75 degrees. Limb little used in walking.

Necropsy. Thickening of the joint capsule. A joint cavity is found anteriorly and posteriorly in the region of the olecranon. In the middle a broad band of adhesions extends across it uniting the humerus to the ulna. On separation the condylar surface is eroded leaving a deep groove in which the adhesions were attached. The rest of the articular surface of the *humerus* is partly bare and shiny. About the margins the dense cortical layer is eaten away and replaced by granulations. On the *ulna* a similar condition is found. The head of the *radius*

is covered by a thick fibrous layer. There are no traces of anything definitely identifiable as flap.

Microscopic examination. Humerus. Transverse section through condyles. A narrow area of dense, bare, cortical bone at the inner margin of the mesial condyle, external to which the cortex is spongy and sinks rapidly into a deep groove, the outer margin of which passes over into another strip of dense cortical bone at the outer margin of the internal condyle. The intercondylar groove is deepened and its walls are formed by spongy bone with a fibrous covering. The mesial two-thirds of the lateral condylar surface is formed by dense, bare bone. The lateral surface of the condyle has a fibrous layer covering a spongy cortex. A cartilaginous osteophyte is seen at the lateral limit of the joint. Where the fibrous covering of the lateral surface of the lateral condyle meets the dense bony surface there is lacunar absorption, showing a tendency toward a fibrous overgrowth and a removal of the bare bony cortex. No remnant of flap over the lateral condyle. On the mesial condyle the deep groove is filled with living vascular fibrous tissue which covers the surface mesially up to the strip of narrow bare bone along the margin, and forms a ledge overhanging the strip of cortical bone on the lateral marign of the mesial condyle. This ledge of tissue is necrotic at its tip and along the surface next to the bare bone. If it is a remnant of a flap complete transformation into fibrous tissue has occurred. The fibrous covering of the groove has a smooth surface, made up of living cells which have a columnar arrangement resembling in places newly formed endothelial lining. New bone formation about the entire margin of the joint.

44-day experiment. Dog No. 57. Elbow. Extensive resection. Free fascia lata flap used. Joint became badly infected but healed promptly. Range of motion 50 degrees. Joint not used.

Necropsy. Thick joint capsule. A cavity is found partitioned anteroposteriorly except in front by a fibrous band. Bony surfaces covered laterally by a fibrous layer which is continuous with the capsule. Portions of the condyles along the groove covered by dense, bare bone in front of which is considerable white, necrotic tissue which may be degenerated flap.

Microscopic examination. Humerus. Transverse section through condyles. Lateral recessus of the joint obliterated. Joint cavity along most of the articular surfaces. In region of external margin of lateral condyle there is a small area of bare, dense, bony surface. From the middle portion of the lateral condyle a broad fibrous band comes off. The surface of a portion of the intercondylar groove is formed by dense, bare, polished bone which is being eaten away by the granulation tissue from either side. There is a joint cavity over the mesial part of the lateral condyle which is grooved and has a fibrous covering with a necrotic surface. Joint cavity is obliterated over the mesial half of the internal condyle which has a thick fibrous covering.

Ulna, transverse section. Articular surface is covered by a thick fibrous layer with a necrotic, villous surface which gives off broad adhesions. Along the crest is a small area of bare, bony surface which is being eaten away by granulations from the sides. Marked new bone formation along the surface beneath the fibrous covering and extensive periosteal new bone about the entire circumference of the ulna.

In this experiment there was marked thickening of the capsule and grooving of the bony surfaces. Fibrous adhesions and bands across the joint space reduced it to a number of small cavities.

58-day experiment. Dog No. 18. Elbow. Articular cartilage and part of the cortical bone removed with a chisel. Free flap of fascia used. Bandage removed on twelfth day. Wound clean. Dog died in 58 days. Range of motion almost complete. Some backward and outward dislocation of the forearm and grating in the joint on manipulation.

Necropsy. The capsule is thin except over the coronoid fossa. Complete cavity present. Entire surface covered by a layer of red granulation tissue except over two areas, one posteriorly and one medially, each 1 cubic centimeter by 1 cubic centimeter, one over each condylar surface and a few very small irregular patches, these areas having a smooth, dense, bare surface and irregular worm-eaten edges. The entire articular surface of the *radius* and *ulna* is covered by red granulation tissue except a narrow strip along the mesial border of the ulnar ridge and a few scattered, very small irregular patches. These areas all have a bare, roughened surface and irregular worm-eaten edges.

Microscopic examination. Humerus. Transverse section through the bare, sclerotic area on internal condyle and fibrous covering of external condyle. Mesial to the sclerotic area the bony surface is irregularly depressed and covered by fibrous granulations which have sequestrated a thin strip of cortical dead bone and have eaten away nearly all of it. The sclerotic portion is smooth and the trabeculæ along the surface contain no bone-cells. The marrow spaces are small and slightly fibrous. The external condyle and intercondylar groove are depressed and have an irregular spongy, bony surface with a thick fibrous covering continuous with the underlying fibrous marrow. Toward the outer limit of the external condyle, there is a small elevation of sclerotic bone with some necrosis superficially and with an irregular thin fibrous covering. The fibrous covering is necrotic along its surface, except over the intercondylar groove where the superficial tissue is partly alive. There is nowhere any evidence of a definite synovial lining.

Ulna. Transverse section. The dense bony ridge is smooth, and shows absence of cells in most of the superficial lacunæ. The underlying marrow spaces are diminished by the formation of new bony lamellæ.

Lateral to this, the bony surface is irregular and spongy with a thick fibrous covering, the outer layer of which is hyaline and necrotic, the deeper portion being richly cellular. No necrotic bone is seen along the surface but scanty new bony trabeculæ form an imperfect cortical rim. This rim increases in thickness toward the periphery where there is a large fibrocartilaginous callus in which an osteophyte is forming. Mesially the sclerotic surface extends to the periphery of the joint surface where there is a large marginal exostosis. The marrow beneath the spongy surface is fibrous for a shallow depth only.

There is nothing about the character of the fibrous covering to indicate whether it is a remnant of the flap or a fibrous outgrowth. The line of junction between the fibrous covering and the bare, cortical ridge is irregular, due to lacunar absorption of the bone by ingrowing granulations. Apparently the dense bony joint surface is gradually being absorbed and the fibrous covering is growing over the entire surface. A portion of the capsule with synovia attached at the side shows considerable hyperplasia with a degenerated lining without any endothelial covering.

26-day experiment. Dog No. 29. Elbow. Quite extensive bone resection. Free flap of fascia lata sutured about end of humerus. Wound clean. Motion rapidly re-established. At end of 62 days flexion to 30 degrees and extension to 120 degrees.

Necropsy. After removing the muscle attachments, the limited motion seemed due principally to the thickened, short, anterior capsule. Upon cutting through the capsule a cavity is found extending over the entire bony surfaces except for a few fibrous bands, the peripheral portions of the condyles and intercondylar space posteriorly. Olecranon and coronoid fossæ are largely obliterated by fibrous tissue. The articular surface of the *humerus* is mostly smooth, dense, and shiny about the margins and in the region of the internal condyle there is extensive absorption of the cortex with grooves filled with fibrous and granulation tissue. Over the posterior half of the external condyle is a thin layer of granulation tissue. All definite traces of the flap are gone. The nodules on the capsule and a few small villi may represent remnants of it. About one-half of the *ulnar* articular surface is covered by dense, smooth, shiny bone, polished by the friction. About the margins posteriorly most of the surface is eaten away and replaced by a thick layer of granulation tissue. The capsule is adherent to the sides of the radial head. The joint surface of the *radius* is partly smooth, partly covered by fibrous tissue growing either from the capsule or remnant of the flap.

Microscopic examination. Humerus. Transverse section through anterior portion. The deep notch in the internal condyle is covered by a loose layer of maturing fibrous tissue. Irregular spongy bone forms its walls. The superficial marrow is slightly fibrous. The bare sclerotic surface extends from the middle of the internal condyle across the intercondylar groove to the middle of the external condyle. It is smooth and the cells of the superficial lacunæ are largely necrotic. The underlying marrow spaces are largely obliterated by new bony lamellæ, the remaining portions being filled with fibrous marrow. The outer surface of the external condyle except a small elevation at the periphery has a depressed bony surface covered by an overgrowing fibrous layer, the cells and scanty blood vessels of which run parallel to the surface. The bony surface beneath this is spongy and shows lacunar absorption. At the junction of the fibrous covering with the elevated sclerotic bony surface there is lacunar absorption, showing the tendency to removal and fibrous overgrowth of the bare sclerotic bone.

This shows well the early extensive sclerosis of the cortex forming the articular surface with subsequent replacement by a fibrous overgrowth.

Ulna. Transverse section through middle of the articular surface shows a large exostosis on the lateral edge of the joint at the seat of the capsular attachment. There is a very large sessile mass of newly formed bone on the mesial edge, and periosteal new bone formation on the posterior surface of the ulna, decreasing in amount as the posterior surface is approached. The mesial recessus of the joint is filled with fibrous tissue and callus. The ridge of the articular surface consists of bare, smooth, dense bone except for a groove in its middle portion where the floor is spongy and shows some lacunar absorption. The groove is filled with fibrous tissue necrotic along its surface. The lateral surface of the ridge is covered by a thin fibrous layer richly cellular along the periphery and mature in its deeper portion with nuclei arranged parallel to the bony surface. As the lateral margin of the joint is approached this deeper layer increases in thickness and represents definitely remnant of the flap. Its superficial portion shows marked hypertrophy and degeneration along the lateral surface of the joint.

There is a remnant of the flap along the lateral articular surface of and recessus about the ulna where it was not subject to pressure. Marked bony hypertrophy about sides of ulna.

63-day experiment. Dog No. 28. Elbow. Resection with chisel. Free fascia lata flap used. Joint became badly infected. Healed in 18 days.

On sixty-third day about 45 degrees of motion. Limb held in flexion and little used.

Necropsy. Joint cavity obliterated except for 2 small spaces, one posteriorly, and one anteriorly along the external condyle. Rather loose fibrous tissue fills the joint space and covers over the articular surfaces, permitting of considerable mobility. When lifted the underlying bone is rough, irregularly worm-eaten. The fibrous tissue blends with the joint capsule at the sides and communicates with the marrow spaces in region of roughened bone.

Microscopic examination. Humerus. Transverse section through anterior portion of condyles. There was a joint cavity over external condyle and intercondylar surface. Covering is a thick layer of fibrous tissue except at outer margin where a narrow strip of the external condyle is bare, smooth, and sclerotic. The bony surface is formed by irregular bony trabeculæ without the reconstruction of a dense cortical layer. It contains little fibrous marrow which extends in places slightly into the underlying cancellous bone. There is little newly formed bone along the surface and much lacunar absorption of the projecting trabeculæ, as evidenced by the giant cells and pocketed surfaces. The covering consists of fibrous tissue which is mature and dense in its deeper portion and irregular and degenerated along the surface where there is more or less adherent débris. This covering is purely fibrous tissue and shows no resemblance to articular cartilage as is shown in some of the older experiments free from infection.

Ulna. Transverse section. The ulnar surface in the region of the joint cavity has a covering similar to that of the humerus. Fibrous tags project from it onto the joint surface where they are markedly degenerated. There is a cut surface of a broad adhesion from the internal surface which extended to the mesial condyle of the humerus.

This infected joint showed a very small cavity, many adhesions, a thick fibrous covering of the entire surfaces, and lacunar absorption in the underlying bone ends. No special cortical sclerosis.

119-days experiment. Dog No. 25. Elbow. Extensive resection of the joint. Free flap of fascia lata sutured over articular end of the humerus. Bandage removed on fourteenth day. Wound clean. Examination 54 days, flexion complete, extension to 110 degrees. Examination 119 days, flexion complete, extension to about 120 degrees. Limb little used in walking. Animal sacrificed.

Necropsy. Articular surfaces are completely covered by a fibrous layer and are separated by loose fibrous adhesions between which particularly about the sides are a number of variable sized cavities. No traces of the flap as such can be identified. Olecranon fossa of *humerus* filled with dense fibrous tissue. Head of the *radius* firmly adherent to the ulna and covered over by fibrous tissue. The mobility of the joint is due to the long, loose, fibrous bands and small cavities.

Microscopic examination. Humerus. Transverse section. There is a fibrous covering over practically the entire articular surface. It is thick over the mesial condyle where the joint cavity was obliterated by adhesions to the mesial surface of the ulna. There is no trace of a joint cavity lining. As the intercondylar groove is approached, the fibrous covering becomes thinner and a fibrous band projects, its surface forming the wall of a cavity. Over the external condyle, the covering is moderately thick and has a joint cavity along its entire surface. In the capsule at the periphery is a cross section of a cavity, with necrotic walls enclosing a small amount of débris. The covering of the external condyle has been transformed into one simulating a normal articular cartilage in that the underlying bone is irregular and an imperfect cortical layer has reformed, the marrow of which is fibrous for a short depth. The cells of the superficial layers are arranged in irregular columns, radiating from the deep layers and many of them contain two or more nuclei. Along the surface the nuclei are few in number and in places are arranged in irregular columns (Fig. 27). Small irregular bony outgrowths into this articular covering are seen. Toward the lateral surface of the external condyle there is definite articular cartilage which may have come from a remnant not removed at operation. In the intercondylar groove the covering is thin, partly ossified, and has little resemblance to joint lining. The surface of the fibrous bands bridging the joint are markedly degenerated but in places contain cells having two or three nuclei resembling those of hyaline cartilage.

Ulna. A transverse section through the joint shows very thick fibrous covering bordering on a cavity which has the same general characteristics as that over the external condyle of the humerus. Over the mesial surface there is also a similar cavity.

Radius. A longitudinal section. Joint surface obliterated about the sides but present over the central portion of the end. Resemblance to normal articular cartilage is less striking than over the humerus. The covering is rich in cellular tissue near the bone where it is continuous with the fibrous marrow. There are a few cells in the tissue bordering on the joint cavity, many of them having two or three nuclei.

Fibrous covering unusually thick but cannot be definitely identified as coming from the surviving portions of the flap. It is thick over all three bony surfaces. The covering of the bony surfaces bordering on the cavities resembles strikingly normal articular cartilage, particularly in the arrangement of the cells. The reason for the complete fibrous covering of the ends of the bones at this

rather early date is to be attributed largely to the extensive resection which was performed.

129-day experiment. Dog No. 72. Small animal. Knee. Considerable bone removed. Free flap of fascia lata interposed between femur and tibia. Wound clean. On the fortieth day flexion to 80 degrees and extension complete. Small amount of lateral mobility. Tibia displaced slightly backward. One hundred and twenty-ninth day, dog killed with ether. Range of motion about 70 degrees. Patella fixed. Limb was little used in walking.

Necropsy. Small cavity beneath the patella which is displaced mesially and adherent to the internal condyle. A rim of new bone has formed about its margin. A joint cavity 3 cubic centimeters by 1½ cubic centimeters is found between tibia and femur. No adhesions have formed in the region of the crucial ligaments. No joint fluid. The anterior surface of the femur above the joint is covered by a fibrous layer. The joint surface of the *femur* is shifted somewhat posteriorly. The articular surface is very uneven and covered by a thick layer of fibrous tissue except in three areas along the posterior margin where dense cortical islands of polished bone are seen. The *tibial surface* is similar, having three corresponding islands. At the outer margin of the joint on the femur are three wartlike exostoses with fibrous or fibrocartilaginous coverings. Remnants of the flap are apparently attached to the back of the tibiopatellar tendon, although all definite traces of the flap have disappeared.

Microscopic examination. Femur. Transverse section through anterior surface of femur in the region of the patella shows the entire surface covered by a thick mature layer of fibrous tissue. The underlying bone is porous and moderately irregular. Over the mesial side which was opposed by the patella, there is an articular surface with a slightly villous lining of poorly cellular fibrous tissue. No evidence of an endothelial lining.

Femur. Transverse section through condyles of femur in region of joint cavity. Joint cavity extends across the entire bony surface. There are joint recessus showing slight villous arthritis and lined by imperfect endothelium on either side at the edges. The lateral portion of the external condyle is deeply eroded, forming a groove with a spongy bony wall filled with a mature fibrous tissue which has a joint lining mesially, but at the side presents a cut surface of an adhesion. The mesial half of the external condyle is covered by dense, bare, polished bone. The intercondylar groove is deepened and filled with fibrous tissue which has a shaggy articular surface. Its walls are of spongy bone but ossification is proceeding into the fibrous tissue filling the groove. The surface of the internal condyle is composed of dense, bare bone except near the lateral margin where there is a small groove filled with fibrous tissue giving off an adhesion and about the mesial margin where there is a fibrous covering resembling slightly newly formed articular cartilage.

Fair joint formation between tibia and femur but marked irregularity of its surfaces. No traces of flap over the femur. Separate cavity beneath patella. Considerable dense bony articular surface present.

129-day experiment. Dog No. 23. Elbow. Resection with chisel. Free flap of fascia used. Upper part of skin wound infected. Healing rapid. On the forty-seventh day 60 degrees of motion. Limb held in flexion and not used in walking. At end of 129 days 40 degrees of motion. Limb little used.

Necropsy. Joint cavity almost entirely obliterated. Motion possible on account of the loose fibrous adhesions separated by many small cavities. Olecranon and coronoid fossæ filled with fibrous tissue and new bone. Articular surfaces mostly covered by a thick shaggy fibrous layer (Fig. 28). Bony surfaces extensively grooved. There are a few bare areas of dense bone. Radius very slightly movable on ulna. Some lipping of joint margins.

Microscopic examination. Humerus. Transverse section through condyles. Surface covered by fibrous tissue except over small part of lateral portion of internal condyle and mesial portion of external condyles. Bony exostoses at the seat of the capsular attachment to the sides of the condyles. Capsule thickened and endothelial lining of the recessus about sides is present. The mesial three-fifths of the internal condyle has a covering which is becoming differentiated into a structure resembling an articular cartilage. The cells of this covering radiate in columns irregularly from the surface; they are more numerous and in places take a hæmatoxylin stain along the bony surface. Superficially the columnar arrangement is less distinct, the nuclei are fewer, the matrix paler. Many of the cells have double nuclei like those of hyaline cartilage. The underlying bone has an irregular dense, cortical layer. Some of the superficial marrow spaces under this contain ossifying fibrous tissue. The surface of the outer third of the mesial condyle is bare, dense, smooth bone. At either side ossification is occurring in the marrow spaces. The intercondylar groove is narrow, markedly depressed and filled with a sparsely cellular fibrous tissue which gives off a broad adhesion on its free surface. The floor of the groove has a spongy, bony wall which shows marked lacunar absorption. Ossification is occurring from the sides of the groove, particularly about the inlet. The surface of the fibrous covering of the groove and adhesion where devoid of pressure resemble a synovial lining (Fig. 29). The mesial third of the lateral condyle has a dense, smooth, bare, bony surface, the most

superficial cells of which are absent, leaving the lacunæ empty. The lateral two-thirds has a depressed bony surface with a thick irregular fibrous covering, part of which lines the joint cavity, part shows a cut surface where adherent to the opposing joint surface. The cortical bone beneath is spongy except near the lateral surface where a new cortical layer has formed in which region the overlying covering shows a slight resemblance to articular cartilage. The rest of the covering is of irregular fibrous tissue radiating from the surface into the adhesive bands.

Ulna. Transverse section through middle of articular surface. Entire surface covered by a thick fibrous layer. Underlying bone dense on the ridge and somewhat irregular on the sides of the joint. The joint space along the ridge partly open and partly obliterated by a fibrous band which has been cut through. The joint surface on the sides is ragged, with numerous small villous tags with necrotic surfaces. The fibrous covering is rich in cells in its deeper layers. It is arranged in irregular wavy bands radiating from the surface in most of its extent, but nowhere resembles closely a regenerated cartilaginous articular surface.

No definite trace of free flap. Articular surface of the humerus and ulna equally covered by a thick fibrous layer, radiating from bony surface. Because of limitation of motion, irregularity of the surface, adhesions and thick fibrous covering, infection was doubtless present within the joint.

137-day experiment. Dog No. 70. Knee-joint. Extensive resection. Free flap of fascia lata under patella and between femur and tibia. Wound healed *per primam.* Bandage removed in 21 days. Fifty-two days limb not used. Joint flail. Extension almost complete. Flexion to 90 degrees. Some posterior mesial dislocation of the tibia. Patella movable. One hundred and thirty seventh day; limb used some in walking. Flexion to 75 degrees. Extension almost complete. Some lateral mobility. Mesial and posterior displacement of tibia. Patella fairly movable. Animal killed.

Necropsy. Capsule thickened. On reflecting the patella downward a small cavity is found between it and the femur. The patellar surface is irregular and covered by a fibrous layer as is the opposing femoral surface. It is difficult to identify remnants of the flap. A moderate sized joint cavity is found between the tibia and femur. There is no septum dividing it. The tibial crest is eroded in its middle portion. There is a fibrous layer ¼ cm. by 1 cm. in size over the posterior mesial portion of the tibia, where there was no pressure from the femur. A transverse band of fibrous tissue just behind the tibiopatellar tendon which may represent flap remnant. The opposing bony articular surfaces are bare, dense, and sclerotic. About the margins fibrous tissue is seen which seems in places to be growing out over the polished surfaces.

Microscopic examination. Femur. Transverse section through the femur at lower border of patellar articulation shows a fairly smooth, somewhat sclerotic bony surface. It is dense next to the bone and is continued into the marrow spaces where evidence of slight new bone formation and absorption of the projecting trabeculæ are seen. This covering is loose in its superficial layers and presents irregular adhesions which apparently connected it with the tibiopatellar tendon and lateral wall of the capsule.

A transverse section through the femoral condyles at points of pressure shows an extremely irregular bony surface with slight exostosis at the sides of the joint. The joint cavity extends mesially slightly beyond the internal condyle. Medial surface of the internal condyle is deeply grooved with a spongy wall and fibrous tissue filling the space. The lateral surface is of dense, polished, bare bone. It was in contact with a similar area on the tibia. The intercondylar groove is deepened, has a spongy wall, and is filled with dense fibrous tissue which has small necrotic villi along the surface. The lateral condyle has an irregular surface.

Extensive erosion and grooving of the articular surfaces had occurred in this joint, due more to friction with the opposing bone than to the action of absorbing connective tissue. Much of the articular surface was still formed by dense polished bone.

RÉSUMÉ OF CHANGES FOLLOWING FREE FLAP OPERATIONS

The changes occurring in the free flap operations are almost identical with those which occur when a pedunculated flap is used. The flap breaks down except along the grooves, about the edges and beyond the articular surfaces where it is subjected to little pressure. Degeneration does not seem to occur any more rapidly than with the pedunculated flap. Surviving portions along the intercondylar grooves show signs of disturbed nutrition as œdema and necrosis, but become attached to the end of one of the bones by granulations which invade the flap from the open marrow spaces (Fig. 26). The free surface bordering on the joint cavity shows the greatest amount of necrosis. Whatever of the flap survives gradually becomes transformed into a fibrous articular covering. In the extensive regions where

the flap disappears, dense shiny, bony, articular surfaces usually form. Grooving from friction of the opposing irregular surface is common. Extensive resection makes less pressure and consequently less necrosis.

Infection causes rapid disappearance of the flap as seen in a number of early suppurating joints which were discarded. Mild infection may be followed by a fairly satisfactory functionating joint as in Experiment 23, 129 days, Fig. 28, but thickening of the capsule, villous arthritis, grooving, and a fibrous covering for the articular surfaces result.

SUMMARY

The changes which follow resection of the articular surfaces and construction of a new joint by the three methods employed are in general as follows:

1. *In the no-flap operations.* A joint cavity forms which is diminished in size because of more or less obliteration of the recesses about the sides from thickening and ossification of the capsule and adhesions of the synovia. Excised portions of the capsule and synovia are rapidly but atypically restored. Villous synovitis is frequently present even in the oldest experiments. Articular surfaces form on the ends of the bones as follows; over the prominent portions which contact with and are pressed upon by the opposing bone, a dense bare bony surface forms which as a result of motion soon becomes smooth and shiny: over the sides, grooves, and depressed portions which are subjected to little or no pressure, a fibrous covering forms by outgrowth from the open cancellous spaces along the surface. With increasing age the fibrous covering usually tends to spread over the entire bony surface, gradually absorbing and replacing the dense bare bony areas. This change is a slow one and in some of the oldest and best functionating joints large bony surfaces were present the process seeming to be at a standstill.

The range of motion varied from 50 degrees to almost normal and generally was greater in the elbow than in the knee-joint.

2. *In the pedunculated flap operations.* The flap early undergoes pressure necrosis and disappears except about the margins and along the grooves where it is not pressed upon. As motion is re-established, more of the remaining portions are destroyed until eventually little of the flap is left. Only a small part of the base of the flap receives its nutrition through the pedicle. Any other portions which survive become attached to the ends of the bones and participate in the formation of a fibrous articular covering for the region.

The changes in the articular surfaces of the ends of the bones are practically identical with those occurring in the no-flap operations. In the regions subjected to pressure, a dense polished bony articular surface forms, while in those subjected to little or no pressure a fibrous covering forms partly by outgrowth from the underlying bony surface and partly from surviving remnants of the flap.

The size and appearance of the re-formed joint cavity and the range of motion were about the same as in the no-flap experiments.

3. *In the free flap operations.* The flaps break down and disappear in the same manner and to about the same extent as in the pedunculated flap operations. The changes in the articular surfaces of the bones and the character and mobility of the reconstructed joint are the same as in the other two sets of experiments.

Infection, prolonged immobilization, displacement, and too extensive and imperfect resection unfavorably influenced all three groups of experiments to about the same degree. *Hence it matters little in experiments on the normal knee and elbow-joints of dogs, whether arthroplasty is performed by the no-flap, pedunculated flap, or free flap method. The flaps when used very largely break down and the newly formed joint is about the same, both structurally and functionally, following the three types of operations.*

It would be unwise to draw too definite conclusions as to the similarity of changes and functional results obtained from operations on these and on human joints ankylosed as a result of disease. While there are many points of resemblance, as the bare bony articular surfaces and the relations of the flap when one is interposed, there are also many

differences. The muscles, tendons, and remaining portions of the capsule are normal in the dog. In the human, as a result of disease and prolonged disuse, the muscles become atrophied, the tendons adherent and the capsule thickened so that it is impossible to obtain early active motion as in the dog. On the other hand this disadvantage is considerably offset by the intelligent co-operation of the patient permitting of the early use of massage and active and passive motion. However, it seems probable that in the operation for mobilization of ankylosed joints, the result will be the same whether or not a flap is interposed. Certainly the most important steps are the construction of a well-fitting new joint, the excision of any thickened or obstructing fibrous tissues and proper after-treatment for the maintainance of mobility.

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PRIMARY HYDATID CYSTS OF THE UTERUS

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OBSERVATIONS on hydatid cysts of the uterus are so rare that the present case deserves mention.

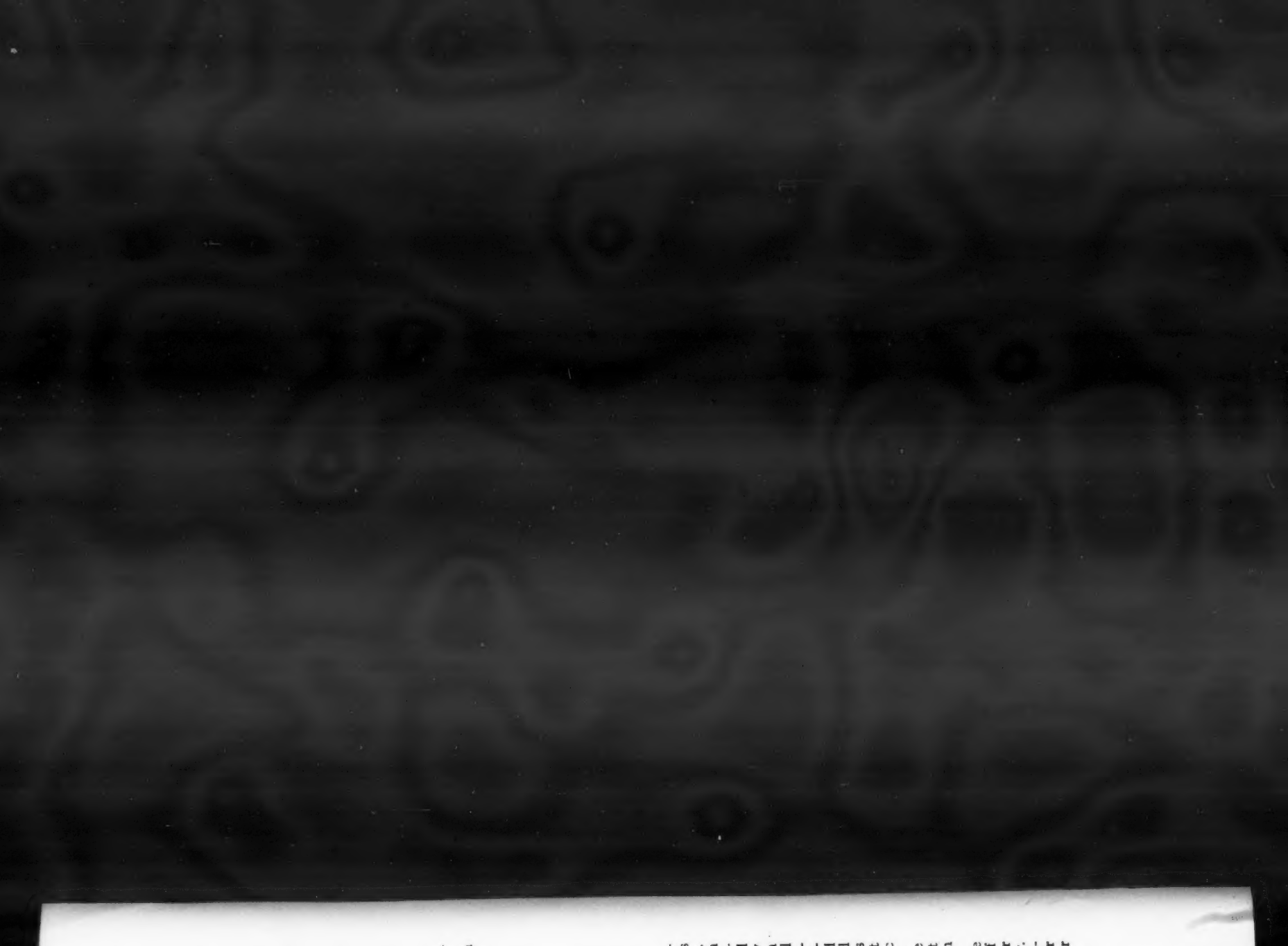
November 15, 1915, Senora Margarita V., of R—— Uruguay, age 47, white, widow for two months, entered my service in the Maternity Clinic She menstruated at 12. The menses had always been abundant and regular, and there never had been amenorrhœa. Her pregnancies, eight in number, had all been normal with normal labors at term. Her first trouble began about two years ago and was characterized by menorrhagia which in the recent months had been very copious.

With the exception of a slightly increased distinctness of the second aortic tone, there is no perceptible organic heart lesion. Urinary analysis gives specific gravity 1005; acid reaction, urea, 7.68 per cent; chlorides 5.275 per cent; albumin; was present and there were a few leucocytes; no casts. The last menstruation began October 27, lasting until November 1, 1915.

Examination on entering the clinic showed the following: Umbilical circumference 87 centimeters, parietal tension diminished; several old skin fissures; there is no complementary circulation, no tympanism, no fluctuation. The hypogastrium is occupied by a median tumefaction, slightly mobile in the laterally and vertically. The vulva with old cicatrices shows neither Sanger's spots nor Jacquemier's sign. There are myrtiform, atrophied caruncles. The perineum shows an old cicatrized laceration of the first degree. The vagina is normal in amplitude; there are anterior and posterior colpocele and cystocele. The fundus is free except anteriorly where the tumefaction noted in the hypogastrium is felt. The uterine neck, irregular and cylindrical in form, is normal in direction and size, with cicatrized old scars; its secretion is normal, both orifices are closed. The body of the uterus is anteverted in normal position, situated vertically, Hegar's and MacDonald's signs are absent. The axial height is 23 centimeters, its anterior face shows a somewhat resistant prominence surrounded by clearly elastic tissue; no fluctuation.

Hysterometry occasioned copious hæmorrhage and gave 16 centimeters. The adnexa were not palpated. The parametrium and pelvic peritoneum showed no alterations.

The clearness of the physical findings and the history of the patient called for the diagnosis of œdematous uterine myoma situated in the anterior face. She was operated upon November 9, 1915, Dr. Curbelo Larrosa assisting and Nurse Chavarria administering the anæsthetic. One cubic centimeter of morphine was given before operation and ether



anæsthesia during operation. With the patient in the Trendelenburg position, a median infra-umbilical incision 15 centimeters long was made. On opening the abdomen the uterus showed every appearance of gravidity, being smooth and congested; the left ovary showed a hypertrophied corpus luteum. A hemispherical resistant prominence was seen on the anterior face of the uterus.

As manual exteriorization was difficult Doyen's helicoidal tractor was used, and on perforation a stream of transparent fluid escaped, apparently amniotic fluid of the first period of pregnancy. At this moment a doubt arose in my mind. We had not verified the last menstruation, the aspect of the uterus was disconcerting; the corpus luteum was exceptionally voluminous; the flow of fluid was not inhibited even by a catgut suture; and copious hæmorrhage persisted. We were convinced of a diagnostic error and thought it dangerous to leave an ovum opened and so decided on a median hysterotomy. At the first stroke of the bistoury the situation was cleared and a white translucent membrane showed through the breech. The cyst appeared to be single and the situation and dimensions of the cavity did not allow other treatment than hysterectomy. This was, therefore, done following the American subtotal method, which was easy and rapid, the left ovary and its hypertrophied corpus luteum also being extracted.

Definite hæmostasis of the uterine pedicle was difficult, due to the constant intrusion of intestinal loops which adequate use of compresses did not control. An acute dilatation of the stomach occurred which reached as far as the hypogastrium and which we were obliged to treat first directly and then through the abdominal wall. Sutures were taken in three planes with a sandbag on the epigastrium. The patient continued well until the 23rd, when an abundant diarrhœa suddenly appeared. This yielded to bismuth and lactic ferment, but reappeared with less intensity on the 25th accompanied by pains in the iliac fossa and hypogastrium. The sutures were drawn on the 27th. The patient got up on the 30th without incident until the evening when suddenly and for the first time there was some fever (37.5° C.); on the following day the temperature fell and the patient

Fig. 1. Specimen removed from author's case.

continued getting up. On December 3, fourteen days after operation, an issue of fluid was noted through the vulva which continued during the night; the hypogastric pain which had persisted for a few days disappeared.

An examination of the patient in dorsal decubitus on December 4, gave no clue to the origin of the escaping fluid. Presuming the existence of a ureteral fistula, a methylene blue test was instituted. The urine showed strong coloration but the vaginal fluid was scarcely tinted. Clinical analysis of this fluid showed: urea 1.28 per cent, chlorides 4.095 per cent, albumin about 15 per cent, no glucose, no evidence of ecchinococci, a few pus globules, leucocytes, uric acid crystals; many bacteria. December 6, absolute rest, vesical *soude à demeure* urotropina. As the loss of urine continued on December 10, Dr. Delger, assistant urologist, made a cystoscopic examination which showed the bladder normal, right ureteral papilla normal. On the left, the orifice was pale and retracted and its ejaculation irregular. Diagnosis: lateral incomplete ureteral fistula. A ureteral catheter was introduced which was well tolerated. From this day all vaginal loss ceased. Drainage by the catheter is perfect although the quantity of urine is less than in spontaneous micturition. The sound was

left in place until December 23. Urotropin was continued with instillations of protargol. By December 28 the patient was considered completely recovered.

Description of specimen. The recently extracted uterus is of somewhat spherical form about 11 to 12 centimeters in diameter. An incision of 25 millimeters opens into a rounded cavity with smooth and shining walls, 8 to 9 centimeters in diameter on the anteroposterior side, and 6 to 7 centimeters on the transversal. The anterior wall is 2 to 3 millimeters thick, while the posterior, which separates it from the uterine cavity, is 3 centimeters. The cavity is created in the anterior face of the uterus. The uterine mucosa is thickened (3 to 4 millimeters) and in general the walls of the organ are hypertrophied. There are no signs of either peri- or parametritis; the extracted adnexa (left) is healthy, increased in volume, and shows a hypertrophied corpus luteum. The extracted membrane shows all the micro- and macroscopic characteristics of hydatid cyst.

As I said in the beginning, cases of hydatid cyst of the uterine tissue are very rare. A great many of the published cases refer to cysts of the cellular tissue, or from the pelvic peritoneum opened spontaneously or punctured through the neck of the uterine cavity when not, as in some old cases simple hydatiform moles confounded by their macroscopic aspect with hydatid vesicules.

In Dr. Salva Mercade's thesis,[1] the bibliography of which is very complete, there are only found 14 cases collected from more than 100 years. Of these only 8 refer to primary uterine cysts.

In our country and in the Argentine Republic in which hydatid cysts are so frequent that in the case of every cystic tumor we ought always think of hydatid disease, I have only found one case, and on inquiring I find that the distinguished Argentine surgeons, Drs. Herrera Vegas and Cranwell, have recently stated that they have knowledge of no other published case.

The cases of primary cysts of the uterus of which I have been able to read are 10 in number, of which I append a résumé.

[1] Cysts and abscesses of the uterus. Paris: 1906.

CASE 1. Wilton, Lancet Lond., 1841. Multipara, 37 years. Uterine hæmorrhages accompanied by expulsive pains. Says that hydatid disease was thought of since the patient showed a loss of transparent fluid. Death by hæmorrhage. Autopsy showed a group of vesicules adherent to the fundus and corresponding to a location in free uterine tissue.

CASE 2. Graily Hewitt, Tr. Obst. Soc., Lond., 1870. Primipara 35 years. Slow evolution 8 to 9 years. Spontaneous expulsion of vesicules. No hæmorrhage. Intra-uterine injection of perchloride of iron 1.3. Intra-uterine palpation showed the presence of hydatids; the patient got up cured 3 weeks later.

CASE 3. Bernard Szancer, Ztschr. f. Geburtsh. u. Gynaek, 1879. Nullipara, 12 years. Emaciated. Abdominal pains; rectal and vesical tenesmus; expulsion of vesicules. Recovery.

CASE 4. Freund, Arch. de tocolog., 1887. Vesicules in the posterior face of the uterus; extracted by posterior colpotomy (Schroeder. Maladies des femmes, Trans. franc. 1886).

CASE 5. Pean and Secheyron. Nullipara, 54 years. Constipation; vesical tenesmus, abdominal pain. Bilateral cervicotomy; extraction. Recovery.

CASE 6. Altormyan, Lancet, Lond., 1891. Primipara, 35 years. Slow evolution, 5 years; abdominal tumor; laparotomy; pediculated hydatid cyst of the uterine wall (fundus). Recovery.

CASE 7. Bergesio, Policlin. di Torino, 1898. Woman of 44 years. Spontaneous painful expulsion of vesicules. Twice curetted and amputation of cervix. Recovery.

CASE 8. Herrera Vegas and Cranwell, Los quistes hidaticos en la Repub. Argent., 1901. Nullipara, 19 years. Abdominal pains, vomiting; 6 months amenorrhœa, diarrhœa; bad general state. Uterine tumor which dilated and obliterated cervix; very tense. Cervicotomy, puncture and drainage. Died ten days later.

CASE 9. Kouzmina, Kyrurgia, 1903. III-para of 21 years. Uterine tumor. Laparotomy. Tumor of the posterior wall and uterine fundus. Supravaginal hysterectomy. The tumor diagnosed fibroma showed hydatid contents.

CASE 10. A Cuzzi, La Ginecologia, 1910, p. 610.

CASE 11. Author's Case. Menopause 2 years ago. Abdomen enlarged, pains. Uterus enlarged, palpation painful; cervix small, some fever. One making hysterometry and dilatation with Hegar's ring, a large quantity of fluid escaped which contained hydatid vesicles. Uterus was much reduced in volume during following days. Recovery?

There is no reason to suppose that in the pathogenesis of these cysts, there is any other mechanism than in the case of such cysts in other organs. The monthly sanguinary flow may explain the relative rareness of implantation in the uterine tissues (Salve Mercade);

and the direction of this drainage facilitates its submucous implantation (Cranwell and Herrara Vegas). But no matter how it happens the relative rareness of uterine implantation is evident since Vegas and Cranwell in 970 observations found only one case; and in the hundreds of cysts observed in Uruguay in the last fifteen years, there is not a single observation of a uterine cyst, while pelvic implantation is far from being rare.

This rarity is increased if we take into account primary cysts, that is to say those cases in which autopsy or clinical observation demonstrates the integrity of the rest of the organism. Our case enters into this category since minute clinical examination has not discovered any other cyst. But I do not deny that this argument is open to question, because we know we can never be sure that there is no other microscopic parenchymatous involvement (hepatic, pulmonary, etc.).

This observation is all the more worthy of being taken into account since multiplication of such cysts is common even in the absence of operative contamination. Personally I saw a short time ago a patient on whom I had operated in 1910 for two cysts of the pelvic cellular tissue and one hepatic, apparently single at that time, and who shows three pelvic cysts and multiple hepatic, as well as being three months pregnant.

Any attempt at a clinical description is unnecessary. Generally, except in cases of vesicular expulsion, a diagnosis is not made. The clinical signs: uterine tumor, hæmorrhage, amplitude of the cavity, conduce to error. Sometimes when there is a fluctuating uterine tumor in a patient who formerly showed other cysts, diagnosis can be made. I do not think that Weinburg's reaction or eosinophilia repeatedly weak or negative, facilitates the diagnosis.

As regards treatment I think that vaginal or abdominal hysterectomy, according to the conditions of the patient (age, general state, dimensions of the tumor, vaginal amplitude, infection, etc.) will be the intervention of choice.

In the case of women capable of being impregnated, and except when the cyst is very small, cystectomy alone will suffice; but the presence of a cavity which, in the majority of cases, must be drained singularly weakens the wall for the evolution of pregnancy. Moreover in cases of prolonged drainage a peritonitis with consequent adhesions is produced which brings about a spontaneous abdominal hysteropexy with all its inconveniences.

Finally I think cystectomy with partial uterine resection is indicated only in the case of very small hydatid cysts.

The prognosis, judging by the published observations, is not bad, when patients have been operated upon before the cyst becomes infected. In our patient the evolution of the case made us think that the last pregnancy co-existed with the cyst without producing any complications.

DEPARTMENT OF TECHNIQUE

THE PARAFFIN–WAX OR CLOSED METHOD OF TREATMENT OF BURNS[1]

By WILLIAM O'NEILL SHERMAN, M.D., F.A.C.S., Pittsburgh

A PERUSAL of medical literature reveals the fact that almost every drug in the pharmacopœia has at some time been used in the treatment of burns. There are countless ointments, mixtures, and methods in use today, all having enthusiastic exponents for their particular efficacy.

Previous to the discovery of antisepsis and for sometime afterward, carron oil was the method of choice. The difficulty of keeping carron oil aseptic has caused it to be generally discarded for picric acid, normal saline, boric ointment, boric acid solution, and the open methods.

Nine years ago, the writer and his associates in the Carnegie Steel Company, attempted to standardize as near as possible, the treatment of burns. At that time, there were many conflicting opinions and it was with difficulty, requiring much persuasion, that we were able to reduce the choice in number of treatments from 18 to 4: i.e., picric acid; normal saline; boric acid; ointment or solution; or open method with dusting powder of stereate of zinc and boric acid.

The same general confusion and misunderstanding exist today throughout the profession in the treatment of burns. There has never been any attempt at standardization because there was little to choose from the various methods; none of the methods being satisfactory and all leaving much to be desired from the standpoint of the patient and physician. Notwithstanding this state of affairs, the general consensus of medical opinion was that we "get good results." The natural question is "What are good results and upon what should our standards be based?" Needless to say, the method which relieves pain and promotes rapid healing with a minimum of cicatricial tissue, is the method of choice.

During the past seven years, the writer and his associates have treated 31,448 first and second degree and 4,683 third degree burns. We have thoroughly and scientifically tried every known method. For the ambulatory cases, boric ointment and picric acid, 0.9 per cent solution, seemed to give the same results. The hospital bed cases have been treated with the "open method," dusting powders, followed by dry heat and boric ointment, etc., as this method seemed to cause the least pain and discomfort to the patient. The removal of gauze which becomes enmeshed in the burned surfaces and granulations is a very painful and barbarous procedure and should be condemned. The continuous bath treatment does not offer any special advantages over other methods and is difficult to carry out where there are a large number of burns to be treated.

One of the basic principles in the treatment of burns has been to exclude the air. This cardinal factor has been well known for centuries. Notwithstanding this recognized principle, not until Barthe de Sandfordt perfected a mixture of paraffin and resin (ambrine) were we able to supply a satisfactory dressing which actually excluded the air.

Sixteen years ago in China, Barthe de Sandfordt, first applied his paraffin wax for the treatment of burns. The results secured caused him to experiment further in the use of these mixtures. Finally a combination was perfected and placed on the market under the trade name of "ambrine." Five years ago, attempts were made to market this product and to introduce the treatment in the United States. They met with failure; first, because the principles advanced were contrary to previous ideas, theories, and practices; second, the treatment was advocated for conditions where it was of questionable value; third, it was a patented preparation. The attempt to popularize the method in France and the United States met with medical opposition and financial failure. Barthe de Sandfordt was looked upon as a crank and in general the method fell into disrepute. The method was unknown in this country despite the fact that the opponents to the method claimed it was not new. Today those who offer the most objections and adversely criticise the method, have not seen it applied in a large series of cases and are ignorant of the cardinal principles underlying it. They maintain that it is "all wrong,"

[1] Submitted by request of the Committee of Medical Research of the Council of National Defense.

Fig. 1. Gas burn, second and third degree. Photograph taken on fifth day. Cured in 33 days, no cicatrices.

Fig. 2. Gas burn, second and third degree. Photograph taken on fifth day. Discharged from hospital on twenty-first day. Cured in 31 days.

simply because it is contrary to their theories and former ideas and because it is a new method. Like every new discovery in medicine, it has had a certain amount of prejudice to overcome. We have frequently been led to except so much from various new discoveries only to have our expectations rudely shattered, that it is only natural that the efficacy of this treatment should be questioned.

Very few who have witnessed this treatment at first hand, have failed to acknowledge its unquestioned superiority over every other known method. It was not until the present war that de Sandfordt was privileged to treat a large series of cases and prove the merits of the method. The writer must confess, it was not without misgivings and doubt, that he visited the hospital at Issy-les-Moulineaux where de Sandfordt was treating a great many burns of all degrees. However, the results obtained were self-evident and spoke eloquently of the new method and it was not difficult to forget former theories and ideas. There was no alternative.

To seal up an infected burn was thought to be contrary to all sound surgical principles. Notwithstanding this, the patients were being dressed without pain; they were recovering two to three times more rapidly than under former methods, and free from cicatricial contraction with a minimum of scar tissue. It must not be assumed that all third and fourth degree burns heal without any scar tissue formation. There is some scar tissue, but it is infinitely less than with any other method and does not have the tendency to contract, so that the frightful disfigurements and loss of function are practically eliminated.

After the first 24 hours, the patient is free from pain in the vast majority of cases. This one factor alone justifies its use. The objection to the method as used at Issy, was the great amount of time consumed in doing the dressings. By improving the technique, this objection has been overcome. Upon the writer's return from Europe in November 1916, immediate efforts were made to improve the technique; at the present time, even the largest burns can be dressed in 5 to 8 minutes without much discomfort or annoyance to the patient. We have treated more than three thousand cases to date and find this method superior to all others. It is now in use at every one of our emergency hospitals as a standard treatment. The men have learned from the experience of their fellow-workmen, the superiority of the paraffin method and ask for it.

Fig. 3. Charles E., age 24, admitted October 29, 1917. Second and third degree burns of left arm, forearm, face, chest, abdomen, scrotum and thigh. Thirty-three to 40 per cent third degree burn. Seventy per cent of burned area healed January 14, without grafting. Complete recovery without necessity of skin grafting very promising. The pulse and temperature reached normal within two and a half weeks. No delirium.

It is useless to compare this method with other methods because of its undoubted superiority. It is an ideal treatment for burns.

PRINCIPLES OF TREATMENT

All burns regardless of character, are thoroughly dried and an air-tight coating of paraffin wax is applied to the burned area, including one-half inch of the immediate margin of skin adjoining the burned area. A thin layer of cotton is then applied which is incorporated into the first film of paraffin wax by painting with a fine varnish brush sufficient wax to completely impregnate the cotton. The wax "sets" in a few seconds. The dressing is then completed by swathing the entire waxed area in cotton and bandages. All burns are redressed every twenty-four hours. The wax method does not contain any specific curative medical ingredients but acts entirely mechanically allowing nature to heal under conditions favorable to repair. The wax cotton dressing is a non-adhesive shell which excludes the air, maintaining a constant temperature and forms a protective dressing to the proliferating tissues under the best physiological conditions, allowing regeneration and restitution along natural lines. The wax serves as a superstructure or scaffolding, and protects the new epithelium which rapidly regenerates. The dressing serves as a poultice, splinting and holding at rest the traumatized tissues. In a short time, secretions form under the dressing which makes it non-adhesive and easy to remove without pain or bleeding or destroying the new regenerated epithelium, thereby facilitating the healing without apparent contracting cicatrices and without causing functional disability. Any paraffin wax which is neutral and has sufficient elasticity and ductility so as not to crack after it is applied, will give good results.

PHYSICAL PROPERTIES OF PARAFFIN WAX

Ambrine is a neutral paraffin and resin compound, which is prepared according to a secret formula. On account of its organic composition, it is impossible to analyze. There are a great many imitations on the market, including cerelene, mulene, parresine, redintol, stanolind, Colonel Hull's formula, etc. Many of these preparations are mere mixtures, while others are specially prepared pharmaceutical products. The wax should be neutral and non-irritating. Paraffin ordinarily contains a trace of sulphuric acid; beeswax contains 12 to 15 per cent cerotic acid and resin contains 10 to 20 per cent various organic acids. These acids should be removed so that the base paraffin wax is neutral. The proportion of materials entering into the combination should be such as to insure a low melting, adhesive, non-brittle, elastic, ductile wax. The wax, if properly made, is a refined pharmaceutical product and not a mere mixture of paraffins. To the wax base, resorcin, oil of eucalyptus, beta naphthol, can be added in proper amounts.

Fig. 4. Several second degree burns; face and hands with slight third degree gas burns, June 14, 1916. Completely healed in 35 days, July 18, 1917. Note absence of cicatrices.

Several different kinds of wax should be available; basic wax containing resorcin and eucalyptus, can be used to advantage.

Ambrine is a very excellent neutral wax having ideal physical properties. Its value can be improved by adding any of the above mentioned drugs. The formula of Colonel Hull, known as No. VII, is more brittle than ambrine and does not adhere to the granulating surfaces as well as some of the other wax preparations, and also contains olive oil, which at times, becomes rancid. The advantage of the Hull formula, is the use of oil of eucalyptus, and beta naphthol, which seems to hasten repair in certain cases and reduces the objectionable odor to some extent.

Paraffin is a very poor solvent for resorcin, chlorazene, beta naphthol, and especially poor for picric acid, while neutral beeswax is a very good solvent for these drugs. It is practically impossible to incorporate any appreciable quantity of picric acid in ambrine, which is largely, paraffin base. There are many grades of paraffines in which there is a wide difference in physical properties.

A neutral flexible wax containing resorcin or oil of eucalyptus will give equally good results. The picric acid should be dissolved in the beeswax and every precaution taken to prevent its settling to the bottom as it is likely to cause an explosion. Certain of the substances contained in the paraffin mixture, fall to the bottom when heated. This is an objection and would not occur if the ingredients were properly introduced. They should have a common meeting point and same relative specific gravity.

A properly prepared pharmaceutical product is solid when cold (very much the same gross physical appearance as beeswax), and becomes as thin as water when heated at 140 to 150° F. It has a very low melting point. Heating 8 to 10 minutes to 250 to 260° F. renders it aseptic. It is analgesic and relieves pain almost entirely after the first 24 hours. The discomfort during the first 24 hours, however, is less than with other treatments. The combination wax cotton dressing forms a shell which acts as a local incubator under which repair and proliferation rapidly take place.

METHOD OF APPLICATION

Equipment. Fine varnish brush, or preferably a paraffin base atomizer; 1 double boiler; 1 electric drier; absorbent cotton divided into very thin layers.

When the patient enters the hospital, the clothing is removed; blebs are punctured, but not excised; and the entire area is thoroughly dried with a Shelton electric hot air drier, or a Hamilton-Beach fan, so that there is no moisture on the surface (an electric fan or common fan may be used). The wax is applied to the burn at the earliest possible opportunity, either with a fine varnish brush or atomizer; preferably with an atomizer. It is difficult to regulate the temperature where the brush is used; it is more or less painful and there is a tendency to brush away and traumatize the new epithelium and granulations. If a brush is used, the wax should be gently daubed on without pressing; to and fro painting movements are painful and should never be used. The frequent changing of brushes is also an ob-

jection. The wax can be sprayed on with an atomizer without pain or discomfort; can be evenly distributed at a given temperature, with no possibility of burning.

The atomizer is double jacketed, a water jacket keeping the wax liquid for thirty minutes after it has been thoroughly heated, and may be operated either with a hand bulb, a compressed air pump, or air tank. The wax is placed in the atomizer and it in turn can be placed either in an autoclave, sterilizer, or on a hot plate. Usually 10 minutes' boiling is sufficient to bring the wax to a proper liquid state. Where a double boiler is used, the wax can be boiled for ten minutes. One must be extremely careful to prevent the splashing of water into the wax. A properly prepared wax, free from water, can be applied directly to a burn or granulating tissue at 150° F., without danger of pain or burning. If the wax comes in contact with water, it is more or less uncomfortable to the patient and the wax does not adhere to the granulations as tightly.

REDRESSING

For the first two or three weeks, or until the granulating area shows a minimum of wound secretion, the dressings should be changed every 24 hours, because in the early stages of the wound there is a rapid sloughing and separation of the tissues, and a large amount of lymph which collects under the shell. This seropurulent liquid gently lifts the wax from the wound so that it does not adhere to the tissues and frequently drains from under the edges of the dressing. The wax shell is readily removed without pain by lifting it from the edges or by making an incision with scissors through the shell and then gently peeling off the shell. The shell slips off very readily. The wound will be found to be freely bathed with lymph and a purulent secretion, and in the early stages, there are sloughing masses which at times become very offensive. This odor is no contra-indication to the continuation of the treatment. The wound is then gently cleansed with a mild antiseptic solution (saline or boric acid solution), great care being taken so as not to disturb the fine film of epithelium which rapidly starts to grow from the edges of the sound skin. Cotton balls can be used to wipe away the secretion. A more desirable method is to use an atomizer to cleanse the wound.

The entire wound is then thoroughly dried, the granulations taking on a smooth, varnished appearance, and the wax is applied as in the primary dressing. At times, the granulations continue to weep in spite of the efforts to dry. This excess of moisture can be removed with blotting paper. The dressing is then completed as previously described. The odor at times in the severe burns is rather nauseating. Where there is a large surface, third and fourth degree burns, with extensive sloughing and absorption of toxins, it is best to apply the Carrel-Dakin or dichloramide T method to reduce the toxæmia and absorption; after the toxæmia has subsided, the wax can be again used. One must change the treatment from time to time depending upon the pathological condition of the wound and clinical condition of the patient.

PRACTICAL FEATURES IN DRESSING AND RECOMMENDATIONS

a. At the first dressing, burns should not be scrubbed with antiseptic solutions. The tissues are sterile as a result of the burning and nothing is to be gained by further traumatizing the tissues. Apply the wax at once, merely sponging will not sterilize the wounds if they are infected, regardless of the antiseptic solution used.

b. Strong antiseptic solutions should not be used in cleansing the burn or granulating tissue at dressing; they should be comparatively weak. The strong antiseptic solutions tend to retard repair. Saline, boric, chlorazene, flavine, brilliant green, or chloramine, can be used in weak solution (preferably in an atomizer).

c. The instructions should be carefully followed. Absorbent cotton should never be applied directly to the burn or wound, as it tends to adhere and stick, causing a burning sensation which is very uncomfortable to the patient. The wax applied alone is a soothing and comfortable dressing.

d. The fetid odor and gray appearance of the wound when the shell is removed should not

Plate I. Condition of patient on arrival in hospital after receiving burns from gasoline explosion. Burns of second and third degree extended over entire face and neck.

Plate II. After three weeks treatment the facial masque peeled off. One notices areas of embryonic epidermal elements which give a milky aspect to the face. At certain points the epidermal cells have united producing the areas of milky white appearance which correspond to the epidermal areas of healing.

Plate III. Condition of injured man after the third ambrine dressing. The yellow parts correspond to burns of the third degree on the superficial layer of the skin; the roseate parts to burns of the second degree. At certain points the eschars reaching deeper than the proteolyzed areas are not yet harmed. The deeply burned areas are commencing to proteolyze and will be eliminated toward the end of the tenth dressing.

Plate IV. After two months of treatment, the picture presents still a very light coloration without any visible scars.

(Colored illustrations by courtesy of Dr. Henri de Rothchild.)

Plate I.

Plate II.

Plate III.

Plate IV.

(The Paraffin-Wax or Closed Method of Treatment of Burns.—William O'Neill Sherman.)

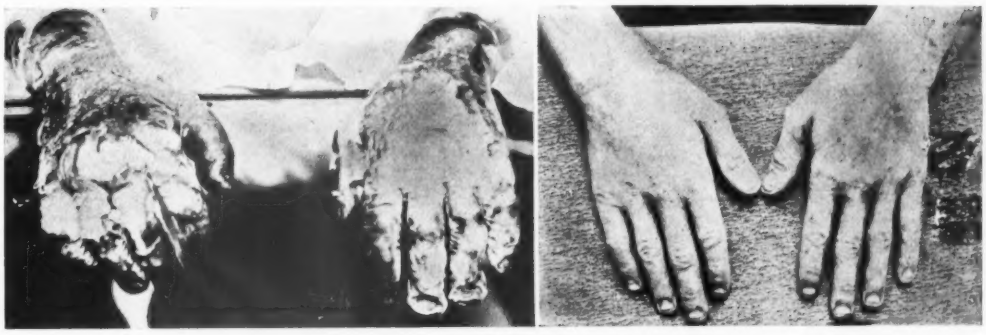


Fig. 5. Very extensive second degree burn of both hands, July 6, 1916, from liquid fire. Burns completely healed. No contractions present; perfect function restored, August 20, 1916.

cause any undue anxiety. After the seropurulent fluid has been washed away and the sloughing tissues separate, granulations with rapid proliferation of epithelium takes place.

e. It is impossible to burn the patient when the atomizer is used. The wax should not be applied at a temperature over 150° F. where the brush is used.

f. In third and fourth degree burns with great loss of tissue, granulations should be sterilized with Carrel-Dakin method and skin grafted at the earliest possible opportunity. Grafting is not necessary unless there has been very extensive destruction of tissue.

g. The application of the heated wax encourages the flow of lymph, protects the capillaries and granulation tissue from trauma which is favorable to rapid repair.

Six months ago, 75 people were burned as a result of the munitions explosion at Essington, Pennsylvania. Dr. R. C. Casselberry had an excellent opportunity to give the paraffin-wax treatment a thorough trial, as well as make comparison with other methods. He writes as follows:

> We consider it far superior to any other method that has been instituted for the treatment of burns. In the first place, from the standpoint of relief of pain, as soon as applied and the ease and comfort compared to other methods in the changing of dressings, is to my mind, one of the greatest advantages. The patient's mental and physical condition improve so much more rapidly when the terror and pain of the redressings are mitigated as they are under this mode of treatment. Some of the cases which had been in agony previous to the application of the paraffin wax were put back to bed and went to sleep inside of 20 minutes. I cannot recall but one or two very bad cases in which we had to give opiates and then only to relieve the mental distress directly following the explosion and not so much for the actual pain involved.
>
> Where slough and discharge became profuse, the Carrel-Dakin technique was used; after the discharge was under control, paraffin wax was again used. The first and second degree burns healed very rapidly, leaving a blush to the surface, but no scar. The skin was soft and pliable with no tenderness. In most of the cases of this character, the skin at this time, August 1, 1917, 15 weeks after the accident, has assumed its natural color and texture. In the more deeply burned cases, there has been some elevated scarring, but very moderate in comparison to the cases treated by oil or other methods. In fact, I have seen some of the scars left by the old method that seem to be criminal; these scars are very much raised and exceedingly tender, which is not the condition where the paraffin wax has been used. Another great advantage is that there is scarcely any contraction of the skin or tendons. Some of the cases treated with other methods are very much disfigured and in many cases, the contractions are so severe that there will always be a limit to their movements, and consequently their value as working people is impaired permanently.
>
> In no instance did we have to resort to skin grafting and there were some very extensive burns, including all parts of the body. I have had practically no trouble following in cases which were treated with paraffin wax, but in the others, I have had painful scars and contractions to contend with; some of the latter have disfiguring scars of the face, but not one of the paraffin treated burns of the face left a scar or contraction.
>
> We used 3 different preparations. The ambrine treated cases showed up best of all. I do not speak ill of any of the paraffin preparations for I feel that any kind of paraffin is superior to other methods.
>
> To sum up, would say the advantages of the paraffin wax treatment are:
>
> 1. Relief from pain to a great degree.
> 2. Cleaner and more comfortable.
> 3. Fewer scars and contractions.
> 4. Skin grafting rare.
> 5. More rapid healing
> 6. Superior in every way to other methods commonly used.

GROWING NEW SKIN IN AMPUTATIONS OR GRANULATING WOUNDS

Experimentally, we have succeeded in growing new skin over amputation stumps. It is very questionable whether this method is advisable in these cases. Sterilization of granulations

Fig. 6. Annular burn, third degree, involving 95 per cent circumference of thigh, exposing popliteal vessels. Photograph taken 7 months after patient was burned. A number of different treatments were used with failure. No repair in 7 months. During this time the patient suffered excruciating pain at dressings. Note extensive contractions. White areas seen on external surface of thigh are light shadows.

Fig. 7. Patient treated with paraffin-wax; 4 small pinch grafts, tenotomy of hamstrings with complete healing of burns and excellent functional result. Dressings were painless from beginning of wax treatment.

followed by skin grafting will give a more satisfactory functional result and materially reduce the convalescent period. Where the granulating area is too small to warrant skin grafting, paraffin wax can be used. New skin can be grown with surprising rapidity. It is also of value in the treatment of "trench feet" and frost bite. The best results are only possible where sound surgical judgment is exercised. Paraffin wax is not a panacea or "cure-all," but if used with discretion and judgment, is a valuable treatment.

PATHOLOGY AND BACTERIOLOGY

During the sloughing stage, a mixed infection is always present: staphylcocci; streptococci; bacillus fetidus, subtilis, proteus and other saphrophytes are to be found, with a profuse, milky, seropurulent fetid discharge as the sloughing tissue rapidly separates through the proteolytic activity of the leucocytes that are thrown out from the underlying granulation tissue, these granulations suddenly make their appearance. The skin growing from the islands and edges of the wound, rapidly proliferates new epithelium. Where there has been total destruction of skin (third and fourth degree burns), the skin grows only from the edges. Upon close examination, a fine film of epithelium can be seen growing around the edges of the wound; this is due to the rapid proliferation of epithelium. It is difficult to say why the cicatricial tissue which forms wherever granulation tissue is present (during the process of healing) is free from contraction, unless it can be attributed to the bland and non-irritating character of the dressing and the optimum conditions afforded by the paraffin film for the protection of delicate epithelial cells (a property of paraffin taken advantage of in the protection of endothelial and blood-cells in transfusion work). It is a well-known fact that nature responds to irritation by the proliferation of scar tissue. The daily application of the ordinary

Fig. 8. Mrs. Anna S., age 26, admitted November 27, 1917. Third degree burn of the abdomen, 80 per cent burned. Annular burn of the left leg, third degree 95 per cent of the thigh involved. Annular burn of the right thigh, third degree 75 per cent of the area involved. Photograph taken January 14, 1918, with 50 per cent of the area healed.

gauze dressing, while unfavorable to the proliferation of the first delicate film of epithelium, furnishes the mild irritation which nature recognizes in the usual way, and the end-result is a thick layer of scar tissue that gives rise to the distressing contractures so frequently met with as an after complication of burns.

The new film of epithelium can be seen growing up and over elevated granulations; these raised granulations are sometimes ⅛ of an inch high. When the skin grows over the elevated granulations, they become flat and even with the surface. The resulting cicatrices are very flexible compared to cicatrices treated by other methods. In no case have we seen a scar interfering with function. It must be remembered, however, that all cicatricial tissue has a tendency to break down if the circulation is in any way impaired.

Bacteriological charts (Carrel) have been kept for observation purposes. In the early stages, the bacterial count (on smear) is usually very high (above 90). During the later stages, the number of microbes found in the granulations decreases. The granulations are never sterile (bacteriologically) unless treated with Carrel's technique. No attempt is made to differentiate the bacteria. One must be able to distinguish between a clinically sterile wound and a bacteriologically sterile wound. Theoretically, all wounds are infected and contain bacteria.

GRANULATIONS

Granulation tissue rapidly appears under the shell and does not bleed when dressing is removed; at times it is very abundant and elevated. It should never be cauterized with silver, copper, sulphate or any other caustic. We have never found occasion to use a caustic. The new epithelium that forms crowds the granulation tissue down in such a manner that it leaves the healed surface soft and pliable, the newly formed skin frequently taking on the gross appearance of normal skin. These granulations are not sterile. On bacterial smear, numerous bacteria, chiefly cocci and saphrophytes will be found in the field. Should the granulations become sluggish, a wax containing resorcin, oil of eucalyptus, or beta naphthol, can be used for the stimulating effect. The Carrel-Dakin method, if applied, will rapidly decrease the number of bacteria in the field; causing the granulations to change their gross appearance and take on a compact, firm, healthy appearance. Where there has been a large surface destroyed (third and fourth degree burns), the repair at times, becomes stationary. This condition becomes more evident in the later stages of the repair; the reparative process becoming slower in later stages and is in proportion to the size of the granulating area.

In the large third and fourth degree burns, the granulations can be sterilized (Carrel-Dakin) after all sloughing tissue has been removed, and

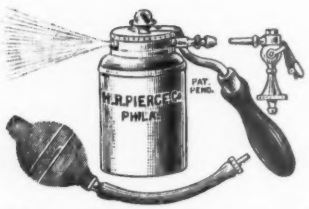


Fig. 9. Author's paraffin-wax atomizer, double jacketed detachable handle. Can be used either with hand bulb, bicycle pump, compressed air or electric motor. Can be heated on hot-plate, autoclave or sterilizer. Wax cannot be heated beyond boiling point of water. A very convenient and satisfactory method of applying the first coating of wax.

then skin grafted (Thiersch method). Following skin graft, the area can be treated by following out Carrel's technique, using 0.25 chlorazene, flavine, or Dakin's hypochlorite solution. This method has been tried out very successfully with encouraging results. Should the granulations become pale and flabby, showing no tendency toward repair, some underlying constitutional condition (frequently syphilis) can often be found. By treatment of this condition, repair rapidly takes place.

INFECTED AND STERILE BURNS

A distinction must be made between clinically sterile and bacteriologically sterile lesions. Burns are clinically and bacteriologically sterile during the first few hours following the receipt of the burn, then all become bacteriologically infected as soon as the skin begins to slough or become necrotic. Smears taken will show large numbers of saphrophytes and cocci which are frequently found in the skin. It will thus be seen that practically every burn becomes infected at some time during the course of healing. This low grade infection, always present in necrotic or sloughing tissue, does not seem to retard repair but seems to be part of the physiological process of repair. To seal up an infected burn so that in any way free drainage is interfered with, has heretofore been considered a surgical error. Should there be clinical evidence of infection with œdema, redness, lymph, angitis, free pus with pain, acceleration of pulse and high temperature, the wax treatment should be stopped immediately and a Carrel dressing applied until the infection has clinically subsided and been confirmed by bacterial smear, after which the wax can again be applied. Where new skin is to be grown and skin grafting is not indicated, the wax can be used after the granulations or infected wound has been sterilized with the Carrel-Dakin method. New skin has been successfully grown in amputation stumps in a remarkably short time after the granulations had previously been sterilized with Dakin's solution.

CHEMICAL, ELECTRIC, AND X-RAY BURNS

Chemical burns: If the burn is acid, an alkali is used to neutralize the acid present; and if alkali, an acid is used; the burned area thoroughly dried and wax applied. We have had several acid burns, first and second degree, in which 5 per cent of surface of the lower extremities was involved, which were cured and the patient in each case was discharged from the hospital in 11 to 12 days, with absolute freedom from pain during treatment.

X-ray burns. Experience is too limited to express any opinion other than the relief from pain which the dressing assures. Mayo reports one case in which an excision had been done for a sluggish burn of more than one year's standing in which the granulating wound covered over satisfactorily with the wax treatment. It will probably have some value in the treatment of X-ray burns.

Case 1. Dr. C. W. reports 2 X-ray burns. Two burns of the sacrococcygeal region, 2 and 3 inches in diameter respectively. The wounds were exceedingly painful, with an intense itching, and were located on the site of cicatricial tissue which resulted from a bed-sore of some 30 years previous. For 9 months, the patient experienced many sleepless nights, was forced to get up during the night on account of the pain and itching. Paraffin-wax was applied, the pain and itching were immediately relieved and the patient was able to sleep every night after the first application. The healing was gradual. The patient was discharged in 4 weeks with complete healing of the wounds.

Case 2. Second degree burn of the left dorsal region. Treatment for 1 year with only partial healing of the wound, which was 3 inches in diameter. The paraffin-wax was applied at the office. On account of the inability of the patient to come to the office, the treatment and technique was explained to an attendant. She reported 6 weeks later with the wound completely healed, stating that at no time since she began the wax treatment did she have enough disturbance or annoyance to prevent her from doing her usual work.

Electrical burns. Holtze reports excellent results in the treatment of electrical burns (30 cases). Pain was relieved and patients recovered more rapidly than with other methods, with no contracting cicatricial tissue. He considers the method far superior to other methods and has standardized it in his service.

SKIN GRAFTING

This procedure is much less frequently resorted to as the great majority of burns heal without it. Where there have been large areas of com-

plete skin destruction, grafting will materially reduce the convalescent period. The grafts should not be applied, however, until the granulations have been sterilized (Carrel-Dakin), the average number of bacteria being 1 to 4 microscopic fields. If skin grafting is resorted to with ambrine treatments, many of the grafts will fail. The best results are to be secured by sterilizing the granulations, then grafting (Thiersch), this to be followed by Carrel's technique, using Dakin's hypochlorite. It is quite possible that weak chlorazene or chloramine-T, or flavine will give equally good results, by keeping the grafts moist, using Carrel tubes and technique. Our cases are as yet too limited in number to say definitely which of the after-treatments is going to be the most successful.

The paraffin wax treatment was used in six cases immediately following the grafting of skin, with 75 per cent successful grafts; in four cases, the application after skin grafting caused a blistering or tendency to break down the grafts. After the granulations have once been sterilized every effort should be made to keep them free from reinfection. This cannot be done if the wax is used, as a sterile wound in 24 hours will show 60 or more bacteria on smear to the microscopic field.

Our latest plan of after-treatment is to carry out the principles of Carrel's technique, using Dakin's hypochlorite solution. The results secured by this method justify a continuation with hopeful anticipations. The after dressing when this technique is used, is quite striking when compared to the physical appearance of dressings treated with former methods. They are clean and dry and odorless, free from wound secretion and sloughing grafts.

Further experiments in the after-treatment will, undoubtedly, develop an improved method which is sure to result in a larger percentage of skin graft successes. It must be borne in mind that one cannot tell from the physical appearance of a granulating wound whether it is infected or not. They must be smeared and the bacteria counted. A wound which might appear to be sterile to the naked eye, might be infected, and a wound which might seem to be infected, may be sterile upon smear examination.

It is unfortunate from all viewpoints that ambrine is a secret preparation, being the property of the Ambrine Company of Paris. It is to be hoped that the formula will be given to the world gratis, because the valuable physical properties of ambrine are almost ideal. Certain of the substitute waxes have satisfactory physical and medicinal properties. This is due to the composition and methods of manufacture. They should be neutral, non-brittle, elastic, flexible, and adhesive and should contain just enough oils and antiseptics to reduce the obnoxious odors and promote stimulation of the newly formed skin. Burns of all degrees heal far more rapidly than with any other method. Pain is reduced to a minimum and healing takes place without contracting scar formation. First and second degree burns usually heal entirely in 12 to 18 days; constitutional symptoms rapidly subside. Many patients recover who would have died under former methods. This opinion is concurred in by all who have had an opportunity to study the treatment. The skin rapidly proliferates from the edges of the wound and from the islands of epithelium which make their spontaneous appearance three or four weeks after receipt of the burn. These islands rapidly grow and coalesce with the growing skin edges or adjacent islands. They begin as pin point grafts, rapidly growing to large size islands. The relief of pain alone justifies its general adoption. Anæsthetics and sedatives are very rarely necessary. The rapidity of repair, relief of pain, absence of contractile cicatrices (scar tissue is present but it does not cause serious contractures) and deformity, absence of local and constitutional symptoms is so remarkable as to be difficult to believe. This method is being used very extensively in the Allied armies and navies. It is to be expected that this method will receive universal recognition and be made the method of choice in the treatment of burns until a superior method is discovered.

SOME FURTHER NOTES ON THE TREATMENT OF BUNIONS[1]

By JOHN L. PORTER, M.D., F.A.C.S., Chicago

IT is nine years since I described an operation for the cure of bunions. Since that time I have performed a great many operations employing practically the same technique, and I am happy to report, with excellent results.

Many operations undertaken for the relief of bunions are unsatisfactory and disappointing, at least so far as the patient is concerned. Why? Because they fail completely to correct the deformity, or else they leave a stiff joint, or both. The reasons for these imperfect results may be any one or more of five, viz: (1) failure to remove enough bone from the metatarsal head; (2) removal of bone from both of the joint surfaces; (3) failure to remove all the obstacles to correction of the deformity; (4) failure to maintain correction for sufficient time after the operation; (5) failure to see that the patient is properly shod after recovery from the operation.

The most common and most potent reasons for failure are the first two. If insufficient bone is removed the deformity cannot be corrected although all the other precautions are observed. If bone is removed from both metatarsal and phalangeal surfaces a stiff joint will surely result.

A most important obstacle to reduction of deformity that is most frequently overlooked is the shortened tendon of the extensor hallucis longus.

With the idea of trying to avoid all the causes of failure, I devised the following technique and have followed it exactly in practically every case, I do not know how many during the past twelve years, without having one dissatisfied patient.

A constrictor may be used but of late I have found it unnecessary. After a thorough preparation including painting the foot with iodine, a crescent-shaped incision two inches long is made just below the edge of the callus which covers the enlarged head of the metatarsal (Fig. 1). I found after several experiments that this incision gives freer access to the joint at exactly the spot where the bone is to be removed than any other, and the resulting scar is just between the points where the upper and sole of the shoe make pressure. I would say at this point that the frequency of occurrence of a true bursa in this region has been greatly exaggerated.

The capsule is incised in the same direction and to the same extent as the skin and the capsule and periosteum are dissected free from the bone by means of an instrument devised by my associate, Dr. P. Lewin, and called a bunion dissector (Fig. 6). The capsule is always adherent to the upper surface of the bone but never to the lower.

The edges of capsule and periosteum are retracted and with a flat chisel and a properly balanced wooden potato masher for a mallet, two-thirds to three-fourths of the head of the metatarsal is removed at such an angle as to include all of the

Fig. 1. Line of incision.

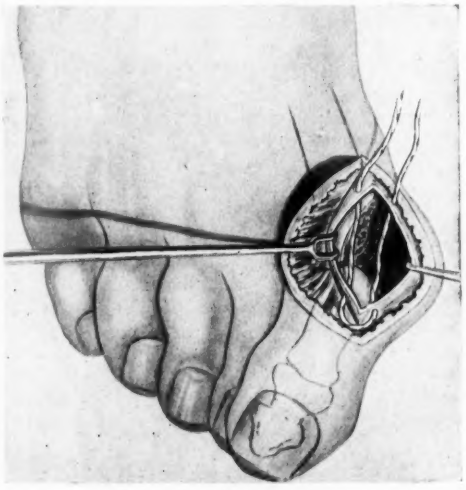


Fig. 2. Bone removed and suture applied.

[1]Surg., Gynec. & Obst., 1909, viii, 89.

Fig. 3. Illustrate a pair of feet before and after a typical operation as described above.

enlarged inner tuberosity. I do not remove all of the head of the bone, for three reasons: (1) It is not necessary. The deformity can be perfectly corrected without doing so. (2) It does not shorten the inner border of the foot and thus make it look unnatural. (3) Motion will be more free if some of the articular surface is left.

After the bone has been removed and all the rough surfaces smoothed the toe is pulled strongly inward and the tendon of the extensor hallucis longus, which is thus brought up into prominence, is divided subcutaneously at the level of the joint. Then it will be found that the toe can, with very little pressure, be made straight. Occasionally I cut the capsule on the opposite side of the toe. This can be done with a tenotome. If a constrictor has been used it should be removed at this time.

While the toe is held in its corrected position a mattress suture of strong 20 to 40 day catgut is carried from the lower angle up to the upper angle, returned through the upper angle and brought out at the lower angle (Fig. 2). The suture is tied thus approximating the upper and lower angles of the capsule incision, and if the proper amount of bone has been removed and the tendon divided, when that suture is tied, the toe will remain straight. If necessary the calloused skin over the bunion may be removed.

The skin wound is then closed with waxed silk, horsehair, silkworm-gut or catgut, Thiersch powder is dusted on, and a thin gauze dressing applied. The tenotomy wound can be closed with one suture. Over the dressing I put a piece of piano felt with a hole in it, shaped like a bunion plaster, and a padded cigar box splint a trifle longer than the foot and somewhat wider than the toe is fastened to the inner border of the foot with adhesive plaster.

The splint is then covered with a bandage starting at the ankle, the splint being fastened firmly to the foot and the toe fastened firmly to the splint with adhesive.

If the other toes are bandaged so as to approach the big toe, the patient will usually feel more comfortable. When the patient is returned to bed the feet should be elevated on pillows and a cradle used to keep the sheets away from the toes.

If the patient is going out from my observation, I apply a plaster-of-Paris cast over the dressing. In many cases where the entire metatarsal arch is dropped, I apply a plaster-of-Paris cast exerting pressure under the arch by means of felt pads.

Fig. 4. Same case as shown in Fig. 3 before and after operation.

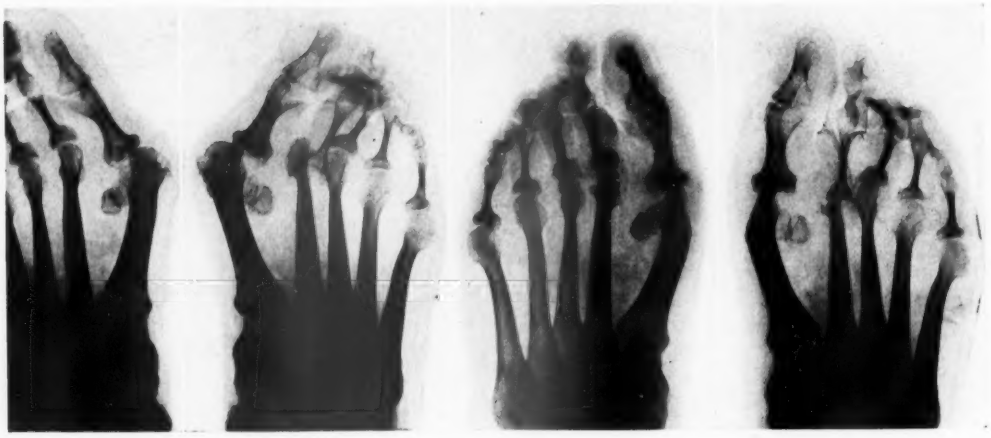


Fig. 5 are roentgenograms of a patient before and after operation.

Unless there is some indication for doing so, I do not disturb the dressing for eight days when the stitches are removed. During this period a large pair of shoes are sent to the instrument maker and a "bunion splint" of spring steel is attached to the inner border of each shoe (Fig. 7*a*). The inner portion of the toe of the shoe is cut away. After the stitches are removed a fresh sterile dressing is applied. A white stocking is cut and sewed so as to make a stall for the big toe. It is put on and the patient puts on the shoe while an assistant guides the big toe which always points downward because of the tenotomy of the extensor hallucis longus. The big toe is secured to the toe splint and the patient wears the shoe day and night for from three to six weeks (Fig. 7*a*). The dressing may be changed every three days. The patient must not remove the splints permanently without consulting the surgeon. She (the great majority are females) is allowed to step on the foot as soon as she can do so comfortably, usually the eighth or ninth day.

The majority of patients after a bunion operation do much better if they wear some support under the transverse arch. This can be accomplished either by insoles padded with felt or by a metal support.

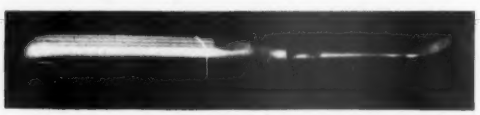


Fig. 6. Lewin's bunion dissector.

For the calluses on the soles so frequently accompanying bunions, the following is recommended: 30 grains of salicylic acid and 20 minims of fluid extract of Cannabis indica, in each half ounce of flexible collodion. This is applied with a camel's hair brush three times a day for several days and then the feet are soaked in hot water. If the calluses reappear, this process may be repeated. A piece of felt cut in the shape of a life preserver with a hole over the callus is a valuable adjunct.

The patient must never again be allowed to wear taper-toed shoes. She is instructed to wear straight-lasted, medium shank shoe with a broad ball. Recently I have been using the "adducted shoe" (Fig. 7*b*). These shoes do not have to be made especially to order as they are manufactured and kept in stock by many companies.

Fig. 7*a* and *b*.

If the pointed shoes are worn the fibrous tissue with which the joint operated upon has been repaired will stretch and the deformity recur. It is not wise to perform the operation if the patient will not agree to wear the shoes prescribed.

COMPLETE ATRESIA AND DISAPPEARANCE OF VAGINA IN A MULTIPARA

By J. F. BALDWIN, M.D., F.A.C.S., Columbus, Ohio

THOROUGH investigation of the Library of the Surgeon General's office by experts has resulted in a complete failure to find on record any case similar to the one reported below. All the textbooks treat briefly of vaginal atresia as it is seen in many old women, but in none of those cases has the atresia been complete, and in none has there been any absorption of the occluded vagina.

Dr. George Gellhorn[1] reports a case of atresia of the lower portion of the vagina in a nullipara aged 74. In this case, owing to cancer of the endometrium, there was hæmorrhage, making a tumor composed of the distended vagina, uterus, and tubes. At his operation he removed the entire tumor, and found that he had brought away, by separating merely the connective tissue, the entire vagina above the point of occlusion. This case, while in a sense related to mine, resembles it chiefly merely in the ease with which the vagina was enucleated from the connective tissue. In his case there was a history of a previous surgical operation for cystocele, made when the patient was 67. At that time an anterior colporrhaphy was made, but there was no atresia of the vagina present, though the uterus had undergone the usual senile atrophy. In my own case there had been eight normal deliveries without any inflammation, and entire absence for any necessity for local operation or treatment of any kind. The atrophic process, therefore, had been without any traumatic etiology.

In reporting his case Dr. Gellhorn made a careful study of the literature, and in a letter from him he states that his search showed no case in any way resembling mine. The case is, therefore, reported as unique, and as a clinical curiosity.

[1] Surg., Gynec. & Obst., 1917, xxiv, 37.

Mrs. M. W., physician Dr. Sparling, London, Ohio. Widow, aged 58. Entered hospital April 2, 1917. She was the mother of eight children, and all her labors had been normal. She had had no miscarriages. She passed the menopause at 43. She was sent in because of bladder trouble which necessitated very frequent urination both day and night. She had been having more or less of this trouble for four years, but had been much worse during the past few months. She had lost considerable flesh, and had had some febrile disturbances connected with the cystitis.

On attempting examination I was promptly informed by the patient that I could make out nothing through the vagina. This I found to be correct, as there was no evidence whatever of the presence of any vagina. Rectal examination showed the uterus moderately enlarged, globular and quite tender. Cystoscopic examination by Dr. Hugh Baldwin showed only a mild degree of cystitis, but pus coming from each kidney. The patient was at once placed upon urinary antiseptics with plenty of liquids, and the bladder trouble promptly cleared up, the absolute rest of the patient probably being largely responsible for the improvement. As the pressure of the uterus upon the bladder had been supposed to have much to do with the cystitis, an operation was done for its removal April 26, Drs. R. J. Behan of Pittsburgh, L. L. Bigelow and H. A. Baldwin of Columbus, being present.

Under the anæsthetic a most thorough examination was made in the hope of finding at least a sinus to represent the vagina, but nothing whatever could be found. Examination with one finger in the rectum, and another in the bladder, showed complete absence of anything resembling vaginal tissue. On opening the abdomen, as previously determined, the uterus was found to be globular, this shape being clearly due to the retention of secretions. An abdominal pan-hysterectomy was, therefore, made in the usual way with the exception that after incising and separating the peritoneum it was found that the cervix was simply held by connective tissue, and that there was no trace whatever of a vagina present. The peritoneal edges of the opening were whipped together with continuous catgut, and the abdomen closed. On examining the uterus, it was found that the cervix was occluded throughout its entire length, and that the distention of the uterus was due to a collection of pus.

The patient made an ideal convalescence, and left the hospital in fine shape in three weeks.

EDITORIALS

HOSPITAL STANDARDIZATION AND TOO MUCH SURGERY

"NO law is such bad law as too much law," said a judge years ago in the analysis of a case before him. Too much law is, no doubt, bad enough, but when the principle is true in surgery, the surplus costs human health and even human life. Through medical literature and through the proceedings of medical societies for many years has sounded an insistent voice, a voice without the tone of oratory, which interrupts and interrupts again. "Unnecessary surgical operations," the voice says, "and operations performed by untrained men are familiar to all of us. What are we to do with the charlatan, with the daring, unsafe, and unprincipled surgeon?" The voice has created many an awkward pause, but through a score of years no answer.

Finally an answer has come. The American College of Surgeons in its plan of hospital standardization makes a straight drive at too much surgery. The plan of the College is neither sentimental nor whimsical. With the good will and co-operation of hospitals, the College directs attention to facts: What was the matter with the patient? What did the doctor do for him? Was the patient relieved or cured? If not, why not?

In other words, the College takes up the keeping of case records and the analyses of these records as its first factor of hospital standardization. It says: "Consistent and fearless review of case records by the hospital staff is a just and effective means to deal with incompetent medical and surgical work. . . . If the facts establish evidence that a physician or surgeon is unsafe in judgment, unworthy in character, untrained, lax, lazy, or careless, in all honor and decency that individual should either overcome his deficiencies or withdraw from practice. Certainly he should neither ask nor receive the privilege of practice in a hospital."

Thoughtful, truthful analyses of case records surely take us to the very aim of the whole profession and of hospitals. Was the patient relieved or cured? If not, why not? Here we have a test of efficiency that is fundamental. It is a test that is sound, simple, and direct. If now the hospitals earnestly carry out the plan, in a comparatively few years the untrained and the unprincipled surgeon will find no hospital-home in which to operate as he is now in many instances free to do. Already the public with determination insists upon such efficiency in hospitals.

Elsewhere in this issue of the Journal is a more complete statement of the College in this connection. That statement recalls to us the homely truth that in almost every community there is a man or two who minds his own business and who seldom has his name in the local papers. He pays his debts, he sees to it that his neighbor is not in want, and he brings up his children with due reverence and obedience. If his country needs him, he is ready. He is all common sense. The hospital standardization plan of the College seems to have sprung out of the common sense of just such men. It touches only upon the essential things which make for the proper

care of patients. For this reason it is a sound beginning and it draws no false lines.

The purpose of these paragraphs is to urge that each doctor, whether or not he is a Fellow of the College, appoint himself as a committee of one to see that the plan be carried out in the hospital or hospitals with which he is associated. There is no such thing as a miracle-person who can do all the work nor who can alone change existing conditions in the practice of medicine. Hospital standardization is an evolution. It is the work of thousands and not of a few.

Again, the College asks that the hospitals meet squarely the practice of division of fees. A farmer was asked what he did through the long winter months. "Oh, I set and think," he replied, "and sometimes I just set." As for the division of fees, it seems that sometimes hospital boards of trustees and hospital staffs "just set." During these naptimes the evil had crept in and become established before many of the hospitals were aware of it. If a hospital is open to fee-splitters, it should be willing to say so and the people of its community have a right to know what this means to them.

But the patient, the patient, the patient! The right care of patients is the aim of all practice of medicine and of hospitals. It is the beginning and the end of hospital standardization and the College clearly emphasizes this view. Let us get to the true facts as to what we do for patients and analyze those facts. "The integrity of the profession requires that each hospital determine whether or not its cases are successfully treated, and if not, why not," the College states. That is what the College means by standardization. The entire work depends upon "constant, earnest effort and sound training, rather than expenditure of money."

TRANSACTIONS OF SOCIETIES

CHICAGO GYNECOLOGICAL SOCIETY

REGULAR MEETING OF THE SOCIETY, HELD FRIDAY, JUNE 15, 1917, WITH THE PRESIDENT DR. CHANNING W. BARRETT, IN THE CHAIR

ABDOMINAL TUMOR CAUSING INTUSSUSCEPTION. PROLAPSE OF PELVIC ORGANS IN A NULLIPARA

DR. CHANNING W. BARRETT: The specimen to which I wish to call the attention of the members of the Society was removed from a young colored woman, 28 years of age, who entered the Cook County Hospital with a diagnosis of pelvic cellulitis. There was a very active discharge from the vagina; there were some large strangulated hæmorrhoids. The uterus was firmly fixed in the pelvis, and there was an indurated condition around the uterus. She had a markedly distended abdomen. The leucocyte count was 15,000 on admission, which afterward went up to 24,000. It was thought from her general condition that she had a pelvic infection, the infection traveling to the peritoneum, with pelvic peritonitis, and more or less general peritonitis, and that this accounted for the distention of the abdomen. She was put upon expectant treatment, but she developed a condition of apparent obstruction, and began to vomit fæcal matter. We were forced to operate, although she was not in a good condition to stand the operation. At the operation the small bowel was found about two and one-half inches in diameter. It was found that the small bowel disappeared in a depression in the side of the large bowel. The specimen shows the cæcum with an intussusception of the small bowel into the large, but the interesting feature of it is that the lowest point in the intussuscepted portion contained a hard nodule, which was first thought to be a portion of the bowel molded into that form. Upon further investigation it was found to be a very hard tumor attached to and depressing the wall of the bowel, so that the tumor projected into the lumen, causing the intussusception. A peristaltic wave caught the tumor, drove it on, and drove the bowel along until it was drawn into the large bowel. That is the interesting feature about this case.

This patient died promptly after the operation but it is probable because of her condition that she would have had a better chance of living, if we had just opened the small bowel and attached it to the abdominal wall and done nothing more at that time. Then if the patient had lived there would now be a fæcal fistula opening upon the abdomen, and this intussuscepted portion of the bowel in the cæcum and colon, which would not be a very ideal condition. What we did was to resect the intussuscepted portion and plant the small bowel into the sigmoid.

I have seen one other case postmortem in which a tumor had been the cause of intussusception. The specimen taken from this case shows it to be a fibroid, and although it projects into the lumen, it is really in the bowel wall, because a portion of the bowel wall covers the tumor.

Another case which I wish to report briefly is that of a woman 42 years of age, operated on this morning. She claims never to have given birth to a child, is not married, and claims not to have been pregnant. Anatomically the conditions bear out that statement, particularly the cervix, the perineum, the absence of striæ and so forth. But she has suffered from prolapse of the pelvic organs; a herniation we might say. She has been operated upon twice before and that the patient had had no children, therefore it was assumed that there was no injury to the pelvic floor. She had been operated on abdominally, but nothing was done perineally for the prolapse. There was a return of the prolapse each time. We found the levator ani muscles lying well to the side, with plenty of opportunity for a hernia. She dates her trouble from an injury received by slipping while lifting. She felt a giving away of something the same as a patient oftentimes does who has an inguinal hernia. The fact of the matter is that probably she had a weak pelvic floor and the lifting or injury was only accessory to that. At any rate, she needed repair of the pelvic floor just as much as a patient who has borne a child.

CARCINOMA OF CÆCUM. RECURRENT PROLAPSUS

DR. EMIL RIES: The two cases reported by Dr. Barrett bring to my mind two cases I have had. One came to me with the complaint of a movable tumor in the abdomen. It was sometimes in the region of the epigastrium and sometimes in the region of the right hypogastrium. I observed her for a few days and when I opened the abdomen I found the following picture: the ileum entered the transverse colon about its middle. There was no cæcum, appendix, ascending colon, or right half of the transverse colon, but it was possible to

draw the bowel back and return the intussusception. I resected about three inches of ileum, the appendix, cæcum, ascending colon, and right half of the transverse colon, and attached the ileum to the transverse colon. That was four years ago. I saw her last week. She had gained over 30 pounds, and was in perfect health. The specimen showed a carcinoma of the cæcum which protruded into the lumen of the bowel.

The second case reported by Dr. Barrett reminds me of a patient on whom I operated ten days ago. She had a recurrent prolapsus and when she came to me I diagnosed a hernia of Douglas' pouch. The cavity of Douglas' pouch went clear down to the perineum, so that the rectum and vagina were not attached to each other as they should be. The peritoneum was stripped up to the height of the cervix, and tied off, as we tie off a hernial sac, and stitched the posterior wall of the vagina, which I had split longitudinally, to the rectum. The patient made a good recovery.

I think these congenital deep cul-de-sacs are not generally known, and the only American author that mentions the condition is Reynolds, who discussed it in a paper on prolapse some time ago. These hernias are a comparatively frequent source of error in the diagnosis of prolapse.

CYSTOCELE

Dr. Theodore J. Doederlein: With reference to cystocele, I was interested in an article I saw in a surgical and gynecological journal by a New York man who described an operation of lifting up the bladder internally. I did that in two cases ten or fifteen weeks ago, in women who had been operated on twice for cystocele. I amputated the cervix, made a high perineorrhaphy, lifted up the bladder internally as though doing a hysterectomy, and brought the broad ligaments together as described. It seems to me that is an ideal operation. If the tissues hold quite well the uterus stays up. It is rather early to report these cases as a success, but the patients are walking about without my having done anything on the bladder below.

OVARIAN CYSTOMA

Dr. Albert Goldspohn: I wish to report briefly the case of a girl, 14 years of age, who had never menstruated, who had attacks of pain, in the third one of which I saw her. These attacks led the family physician to think that she had some abnormal development and retained menstrual blood. The child had become septic with a temperature of 101.2°, white blood count 20,000, with a pulse of 130 and apparently a diffuse peritonitis. Examination showed nothing abnormal in development from below. If the tumor felt by the family physician was really retained blood, then it could only be an abnormally closed horn of the uterus. But abdominal section showed it to be an ordinary ovarian cystoma springing from the right ovary, developing in the left side, filling the entire pelvis, but crowding the uterus toward the right, with some five revolutions of the pedicle.

The odd thing is a cyst of that size in a child that had never menstruated. Before it was emptied, its color was bluish black. The removal of the cyst was easy. The child is now in good condition.

URATE STONE IN TUMOR OF URETER

Dr. Emil Ries: The first specimen is from a woman who had painful urination for eight years. She had had an appendectomy and bladder treatment for cystitis but had not undergone a cystoscopic examination. She complained of frequent and very painful urination. There was some laceration, some descensus of the uterus and vagina. On cystoscopic examination, I found the right ureter normal. I could not see the left ureter because there was a tumor about the size of my little finger, which was slightly warty, and at the tip of which was a little crescentic opening. I tried to enter the ureter with a catheter, but the catheter would not enter the opening. The tumor was movable. I could not find the ureter at the base of the tumor. I then did a suprapubic section, exposed the bladder, and found the tumor as seen with the cystoscope, and when I took hold of it, I found in the midst of the tumor a hard body which was a urate stone in the ureter. This could not be removed through the opening of the ureter without incising the tumor, which was the inverted ureter protruding into the bladder.

LUETIC CONDYLOMATA

The second specimen is from a woman, 57 years of age. There had been a bloody and purulent discharge from the vagina for about three weeks. She had not menstruated for several years. On examination I found two tumors close to the cervix and two lower in the vagina about an inch and a half long and three-eighths of an inch high each. The question arose as to the possibility of condylomata in the vagina. The Wassermann test was negative but microscopic examination of excised tumors revealed typical luetic condylomata. She admitted then the probability of and examination proved the source of her luetic infection. The Wassermann test was negative because in the first stage of syphilis it is not as reliable as later. A Wassermann test has since been made and found positive, and the tumors have disappeared under antisyphilitic treatment. Tumors in the vagina of this size are rare.

DERMOID CYST

The next case is the smallest dermoid I have ever seen. This small dermoid was on the surface of an ovarian cystoma of very large size. I operated on the woman for an ovarian tumor which contained a clear serous fluid, and on microscopic examination the wall was devoid of epithelium, evidently a

simple serous cystoma; but in the wall on the outside I could see a little bleb not thicker than half an inch and about 2 inches in circumference. When I opened it out came typical dermoid material, the fatty material of the dermoid. I have cut it open and you can see in the center of the dermoid the characteristic dermoid peg which all dermoids show.

ADENOCARCINOMA OF VAGINA

Another patient, a woman, 46 years of age, came to the Michael Reese Hospital complaining of a bloody discharge. She had an enlarged uterus and symptoms of carcinoma in the body of the uterus. I did a curettement to make the diagnosis, and immediately got out a large chunk of material, which looked carcinomatous. I turned it over to the pathologist for examination while I went on with the abdominal hysterectomy. There were no wounds made in the vagina, except what we made during the curettement in taking hold of the cervix. The cervix was sewed up before I did the abdominal hysterectomy. The woman made a smooth recovery. I made a Pfannenstiel incision which healed by primary intention. Eighteen months later the woman came to me complaining she felt small tumors on the left side of her vagina. When I looked for these small tumors I found there were two small red warts barely as large as the kernel of a hazelnut. I concluded they were carcinoma. I made a paravaginal incision, extirpated the entire vagina, reopened the Pfannenstiel incision, and extirpated the inguinal glands completely. On microscopic examination I found that both of these tumors in the vagina, which were separated by half an inch of tissue, were typical adenocarcinoma.

How does a woman get adenocarcinoma in the vagina? A vagina that has stratified epithelium should never develop adeno carcinoma, but this woman came with metastases in the vagina eighteen months after an operation for adenocarcinoma of the body of the uterus. If in the course of operation, as has happened in many cases before, any wound is made, if for instance the carcinoma is operated on with a Schuchardt incision, this incision may have some carcinomatous material grafted into it; but in this case no paravaginal incision was made; there was no injury to the vagina; the posterior wall was protected by speculum, and the cervix was sewed up before we did the hysterectomy. Of course, we understand in the vagina now and then, glands and small cysts are present. One of the sections of adenocarcinoma of the vagina showed at the edge of the carcinoma a small cyst with a single layer of cuboidal epithelium, but this cyst has undergone no degeneration whatever. There is no trace of proliferation of the epithelium in this cyst, and there is no evidence of connection between the cyst and the carcinoma. The cyst is an accidental finding by the side of the carcinoma. If this woman had carcinoma grafted into her vagina, it is very hard to conceive that that carcinoma should have remained dormant for eighteen months and then developed into these tumors. I have examined the woman many times in the course of the eighteen months because I wanted to be sure the carcinoma had healed. I never found any tumor in the vagina until she came eighteen months afterward. If she had carcinoma of the body of the uterus and had lymphatic metastases following the lymphatics of the vagina, and these metastases grew out in the vagina, we should find some carcinoma in the lymphatics of the vagina under the epithelium in the neighborhood of the tumors. I have examined the tumors in serial sections, and have cut over five hundred sections from many areas of the vagina, but there is not a trace of carcinoma in them.

This case is remarkable because of the late recurrence. All we can say is that it is metastatic carcinoma from carcinoma of the body, typical adenocarcinoma in the vagina.

I should like to hear from the members as to whether they have had similar cases because I have never read or heard of such a case.

Recurrences of the nature of implantation metastases in the vagina six weeks or two or three months after operation are frequent; but implantation metastases eighteen months after operation with repeated negative examinations in the meantime is something new to me.

TOXÆMIA OF PREGNANCY

Dr. Mark Goldstine: The first case is a woman, 42 years of age, in her first pregnancy, which was approximately six and a half months advanced. Fortunately, this woman was examined on a Saturday previous to the Monday when she became sick. When examined she was apparently in good condition as far as we could determine. On Monday I saw her, and she told me she was taken ill Sunday afternoon, and on Monday she presented a typical picture of the toxæmia of pregnancy. There was a good deal of diminution in the amount of urine passed; there was marked œdema, not only of the legs but of the rest of the body; she had headache, vomiting, and a slow pulse. Her temperature was normal. Her blood pressure on Monday was about 160. She became steadily worse from day to day, so that in about 10 days a 24 hour specimen was but 14 ounces of urine. One 24 hour specimen was but 9 ounces. She continued so for about 3 days. Her blood pressure was then 210 in the morning and afternoon. She was vomiting everything she took. There was a large amount of œdema all over the body. She had a persistent headache, and marked eye symptoms. After a good deal of deliberation we decided to empty the uterus (this was a Friday October 24). In the afternoon of the 25th she became very drowsy and started to perspire, although she felt quite well that evening. That night she had a very good night, the best night she had had since she became sick. The next day was a good one; she perspired freely and wanted something to

eat. She passed a good deal more urine, so that from the 26th to the 27th we got 36 ounces of urine. There was a marked improvement in her condition from the 29th to 30th. The morning of the 26th she felt life. I could elicit heart-tones in the lower quadrant of the abdomen, but when I saw her that afternoon I could not get them. She continued to improve. On the 24th of November, there was apparently death of the fœtus, and she delivered herself of a macerated fœtus, weighing three pounds. She made a good recovery.

In this case one of the findings was creatinin in the blood which went up to 5.2 per cent. According to the reports on that work under normal conditions, where these patients get 5 per cent of creatinin in the blood, they do not recover, showing that in this case these findings did not hold good. After the death of the fœtus, the creatinin dropped to 3.4 per cent.

This is an interesting case of toxæmia because of the sudden onset. A remarkable improvement occurred with the death of the fœtus.

Dr. Goldstine reported two cases of carcinoma of the uterus and one of probable cancer of the gall-bladder with ovarian metastases.

TREATMENT OF SEPTIC ABORTION

Dr. Emil Ries read a paper entitled "The Treatment of Septic Abortion." (See p. 400.)

DISCUSSION

Dr. Rudolph W. Holmes: A paper of such fundamental importance as this should not pass without full and favorable comment. In the years that I was chairman of the Abortion Committee of the Chicago Medical Society it was my fortune to see a large number of cases of septic abortion, all due to criminal procedures. Oftentimes we had the legal responsibility placed upon the head of a physician or midwife, although the responsibility rested upon him who had performed the criminal act, nevertheless, the death was undoubtedly due to the physician who performed the so-called "life saving operation," sequential to the criminal attack. In other words, death was directly due to the meddlesome midwifery of the doctor. Dr. Watkins worked out this problem many years ago: adopting his suggestion, I have in a great measure pursued his course, which is along the essential lines of Dr. Ries.

The fallacy of the opinion of those who believe in the routine curettage is evidenced by the fact that it is impossible to curette *completely*, any uterus; in fact, the curette rarely will cover much more than one-half or at most little more than this amount of surface. At one time I believed it an essential part in the preparation for an hysterectomy to curette, and then swab out with iodine. In no instance was the curettage complete, and in fact, no uterine cavity showed that the iodine had stained the entire mucosa. If we do a curettage, we should clearly recognize it as a partial operation. As a prophylactic measure in hæmorrhage, curettage has a valid place. For sepsis it does little more than stir up an inflammation.

In 1905, I brought out a small contribution on the conservative treatment of puerperal sepsis. These lines I have followed since, modifying them as I felt I had developed my knowledge of the means at our disposal. They are largely along the lines described by Dr. Ries.

Where it is fairly definitely proved that infection is due to the streptococcus it may be a grave menace to enter the uterus. Whatever may be in the uterine cavity is of small significance. On the other hand, in a putrid infection, with definite necrotic decidua or placenta retained, a digital removal will prove of inestimable value. I have repeatedly seen women who have foul, odorous discharges for a protracted period, have an almost immediate return of normal temperature after such digital removal of the uterine contents.

Dr. Joseph B. De Lee: I am very glad Dr. Ries again brings to our attention this very vital subject, the expectant treatment of sepsis in the puerperium—the puerperium that follows both abortion and labor. This was a comparatively new thing in Chicago and even yet, as we all know, the expectant treatment of sepsis is not generally practiced.

I desire to take the credit for being the first in Chicago to have insisted upon the expectant treatment of puerperal sepsis. In the latter part of 1897 I read a paper before the Chicago Medical Society upon the "Treatment of Puerperal Infection" in which I brought out the noninterfering treatment. Naturally I was very severely criticized in the discussion. I practiced that method of treatment, not as the result of any experimentation or any bacteriologic or pathologic study, but simply as a matter of clinical expedience, which was due to the impossibility of carrying out the established methods of treatment. I was then doing a large part of the work in the Chicago Lying-In Hospital, and with the fever cases that occurred it was impossible for me to give each woman a curettage and douches, applications of iodine, and so on, that were then in vogue. Several patients had to go one to three days before I got around to give the treatment. In the meantime they got well, and when I came prepared to douche, to curette and sponge the patients did not need it, and after a while I took courage and did not give them the treatments the books demanded and which I had been taught. After a year and a half of such experience I read this paper. Shortly after that, in the year 1900, I gave up the removal of infected placentæ. Up to that time I felt that one thorough cleaning out of the uterus was justifiable. I gave up the removal of the infected material in the uterus after delivery, but treated abortion by the removal of the secundines. About that time my associate, Dr. Stowe, entered the Cook County Hospital and tried to carry out the treatment I had taught him. He also tried to

carry out the treatment that had been taught him at college, which was to remove immediately the placenta, membranes, and so forth. His results were such that he thought he would go back to the treatment I had taught him. He came around entirely under my own banner.

Since the early years of this century the practice at the Chicago Lying-In Hospital has been non-interference in septic abortions. We pursue at the dispensary a more active treatment in the cleaning out of the uterus in cases of simple abortion, but it is largely a matter of expediency. Sometimes the ignorant women allow themselves to bleed more than they should. We find it inexpedient to wait for spontaneous abortions, and our practice has been, if the hæmorrhage is at all considerable, to pack the vagina, and the next day come prepared to curette. After the cervix is dilated the uterus is curetted by finger or by instrument, and if the cervix is not dilated, we pack again, and then the next day, almost invariably the conditions are such that the uterus may be safely emptied.

Dr. Ries' paper left one point unclear to me. He says, in cases where it is necessary in septic abortion to pack for hæmorrhage, he does so, and the next day he removes the packing. He curettes either by finger or by instrument and dilates the cervix, if necessary, with Hegar dilators. My teaching is different. If at that time the hæmorrhage has ceased, and removal of the packing makes one think that hæmorrhage has definitely ceased, I teach not to pack, not to curette, but to wait another day or two and then pack again. This is rendered possible because such cases are always taken to the hospital where the interne can pack in emergency if after two or three hours the packing being removed, the woman bleeds again.

Another point Dr. Ries brought out is this: He does not use packing unless it is unavoidable, and he does not use the pre-operative antiseptic douche. I still use the pre-operative antiseptic douche when I have to go into a septic uterus, the object being not so much to disinfect the surface and kill off the germs there existing, but to remove as much as possible both mechanically by the douche and by reducing the vitality of the germs in the secretions and in the placenta, to reduce as much as possible the amount of infected material which is unavoidably ground into the uterine wall by the manipulations. The strength of the douche is not sufficient to kill the germs, and furthermore, within a few minutes they are far beyond the reach of any douche or curette. After the uterus is cleaned out I put in occasionally a little iodoform packing because when that packing is removed little shreds of membrane and little bits of placenta which have escaped the curette are brought out, leaving the uterus clean and smooth. It stimulates the uterus to contract and helps to close up the lymphatics and possibly the blood vessels.

In spite of the report of the Committee of the American Medical Association four years ago, in which it was conclusively shown that the expectant plan of treatment led to success, and copies of which report were sent to every professor and every assistant professor of obstetrics in the United States, there still emanates from medical colleges the evil of active treatment. Parametritis, tube infections, pelvic abscesses, chronic pelvic peritonitis resulting in deformities of the uterus, too often follow manipulations.

Dr. Albert Goldspohn: I did not expect to speak on this subject, because I have largely evaded the practice of obstetrics for the last fifteen years. But I have not escaped pathological labors and incomplete or septic abortions that are brought to hospitals.

Great improvement certainly has been made over the old methods of treatment of septic abortions. However, expressions to the effect that the intra-uterine douche is equivalent to idiocy and that intra-uterine interference is always reprehensible are as devoid of sense and reason as were the extremists for intervention. The normal drainage of the post-partum or postabortum uterus sometimes becomes interrupted. This may be either by remnants of secundines clogging the cervical canal; and then a single intra-uterine douche carefully given with the proper tube, without a vaginal speculum, without changing the position of the uterus and without drawing blood, will often reinstate a nearly normal status in place of alarming conditions, with one stroke. Again the interference with a normal flow of lochia may occur in a sagged down or retroverted uterus that can not empty itself by gravity. Portentous of evil as such a status is in the presence of infection, — the faith-cure, on-looking doctor is even unaware of its presence, although it is amenable to packing and correct posture of the patient.

The douche tube that I use, if any, in puerperal cases is a large one of the Bosmen type, devised years ago by Howard Kelly. Being about 2 cubic meters in diameter, it can not make wounds. All use of a curette or of forceps in a puerperal uterus should be with a distinct aim and most studious effort not to wound the mucous membrane in the uterine cavity, but merely to rake out accessible remnants of secundines that project above the level. This distinct and vital purpose clearly forbids the use of all ordinary gynecological curettes and douche tubes, because on account of their small size, they are too liable to injure the interior lining of the puerperal uterus, that has been drawn into folds within the suddenly contracted cavity. The curette of first choice should be the finger when possible. Other curettes should be semisharp and with large loops. I devised one years ago with a loop 2 centimeters wide and with a canulated handle through which the mechanical and antiseptic effect of a current of a suitable solution (lysol) can be maintained upon all wounded areas, to prevent the ingrafting of septic detritus during the curettement.

Dr. Rachelle S. Yarros: I am going to speak briefly of the type of cases that I see. Cases that

are advanced as far as 4, 5 or 6 months, as we see them, receive entirely different treatment. If the fœtus has passed and the woman has some elevation of temperature, we realize that unless there is hæmorrhage it is better to leave the placenta alone, not to remove it manually. I think probably all of you will agree that in these cases the best plan is the expectant treatment. But it is the early cases I see, cases of 3, 4, 5, and 6 weeks' duration. These cases usually come to me with hæmorrhage or they are sent to the hospital with hæmorrhage. I do not like to treat such cases in private houses. When a woman has hæmorrhage and elevation of temperature, and hæmorrhage without temperature I curette, and I have not had a single bad result in the last six or seven years from curettage. We have to judge from our own experience. I think careful curettage in these cases is just as good treatment because the results are just as good, and although I agree it is a wise thing to print this paper in blue and red ink so that the people may awaken to a realization of the importance of the subject, still I am inclined to think that the extreme statement in regard to packing is likely to inspire people with fear of proper curettage.

Dr. Mark Goldstine: It is fortunate if one can have experience with both lines of treatment, and I was fortunate that way. While I was in Dublin at the Rotunda a very active treatment of puerperal infection was carried out thoroughly.

The mortality unfortunately between the two treatments is not high enough to make the men who are radical back down, but if they only had experience in both lines of treatment as to the morbidity, they would soon stop radical treatment.

If I remember my statistics correctly, for those patients upon whom curettage and douching were done, I find the average stay in the hospital when conservative treatment was followed was 26 days, while in Dublin the average stay in the hospital was many days longer. In almost every case of puerperal sepsis over there, we had a pelvic abscess to open. Pyæmia, which is a rare condition here, was a common condition over there, and it was not unusual to have a patient in the hospital three or four months, and when we got them through we thought it was a strong plea for our treatment.

I am conservative to the last degree. I will not go into a septic uterus under any circumstances whatsoever unless there is hæmorrhage, and it has to be a severe hæmorrhage for me to go in. I am never afraid to let the placenta remain and I am not afraid to let the fœtus remain. It is a clinical fact, as Dr. Ries mentioned in his paper, that in septic abortion, before the uterus empties itself the temperature will shoot high, and after that high temperature the uterus will empty itself. I think it is criminal to go into a septic uterus unless you have great provocation to do so.

Dr. Channing W. Barrett: I would like to say a few words on this subject. A good deal has been said in regard to priority of the conservative line of treatment in septic abortion. I would like to claim some priority, too, that is, the priority of always objecting to the ultraconservative form of treatment in cases of septic abortion.

If I wanted some evidence to offer here in favor of the benefits of emptying the uterus, I would want nothing better than the diagrams or charts which were thrown upon the screen. Dr. Ries pointed out with considerable satisfaction how the temperature dropped immediately when the uterus was emptied, whether it was by manual cleaning out or whether it was spontaneous. I would say also, if I had the choice with my patients or my family of having the conservative line of treatment, or the very radical line of treatment, I would prefer the conservative line of treatment because these women do not all die with the conservative line of treatment. They do not all die by either method of treatment, but too many of them die.

Dr. Holmes' illustration of not being able to curette the uterus has nothing to do with the question. We are not talking about curetting the uterus, but we are talking about removing foreign material from the uterus. Any line of treatment that presumes the scraping over of the whole surface in a septic condition is going to produce more damage than benefit. There is nothing that the treatment of abortion shows more definitely than that a patient is better off with the uterus emptied; and that is just as true of puerperal conditions at full term, only there is not so apt to be foreign material in the uterus. All who have spoken have felt satisfied after the placenta has come away. If it makes no difference whether material is left in the uterus or not, why does the practitioner examine so carefully to see if there is a little material left in? The uterus does not empty itself well after abortion, and it has not reached that ripe condition for empyting itself, consequently there is a tendency for foreign material to be left in the uterus.

There is a line of treatment for abortion that is very safe, and that is the thorough cleaning out that goes with therapeutic abortion. The patient who has a therapeutic abortion almost always does well, even though she had to have the uterus emptied because of a kidney condition, or because of a heart or lung condition. Such women always do well. I do not mean that they all recover from the heart condition or the kidney condition, but as far as the abortion is concerned they do well. One reason for that is the complete emptying of the uterus, and the other reason is that the element of sepsis has not entered there. But it is the uteri that have foreign material in them that give the mortality.

I have had some experience with the treatment of abortions. Any one who has been on the service at Cook County Hospital must have had some of these cases, and the ones that come in in the worse condition are the ones that have had conservative treatment. After the removal of the placenta the temperature drops down to normal. We have had that same line of treatment in relation to the

appendix. Along in the eighties it was found out that a certain patient had appendicitis and the radical line of treatment was carried out. The appendix was removed. The patient had inflammation of the omentum and was operated on for it, and they took out a piece of the omentum. The patient had the two bowels matted all together. They killed patients by that radical line of treatment for appendicitis, because they were operating against the thing that was doing the patient the most good. A good conservative line of treatment is offered as a substitute.

If I had my choice between the conservative line of treatment for appendicitis and the radical treatment of tearing about the abdomen, I would choose conservative treatment, but I would not select the conservative treatment for appendicitis as against a very conservative operation of opening for the infection, giving it a chance to get out, and removing the gangrenous appendix.

The line of treatment that I have been carrying out with great satisfaction carries with it douching of the uterus, and I prefer to douche with a mild tincture of iodine solution before undertaking to remove or wash out any foreign material that is there. Some one has said that sepsis has spread beyond washing out. One man might overcome one soldier, but he could not very well overcome ten. A patient may overcome some sepsis in the wall of the uterus, but not be able to overcome the amount of it pouring in. One germ in a little while will become a million. In the case of drainage of the appendix the patient is able to overcome oftentimes the infection that is left, but would not be able to overcome all that is there, and I believe that is the case here. No one doubts that if this is a saprophytic infection the patient will stand it any way, and if it is not a saprophytic infection there is no use in removing this or in helping the uterus to remove it. It is not a saprophytic infeotion that attacks placental tissue entirely; it may be the most virulent kind of infection. If the placenta is still attached it may furnish a good culture medium for germs, and be in a very poor condition to fight these germs, and the removal of that not only removes a large part of the infection, but it gives the uterus a chance to contract. If you empty the uterus, you will find that the contracted uterus furnishes the patient the best opportunity to fight infection.

Dr. Julius E. Lackner: I reported 500 cases occurring in the service of Drs. Banga and Frankenthal at the Michael Reese Hospital in the years 1909 to 1914. Of these 500 cases 4 died. Of these 4, one was treated conservatively, the other three actively.

The treatment at the Michael Reese Hospital is by tent dilatation for 24 hours previous to curettage, and then digital emptying of the uterus, followed by half per cent iodine douche. Some of these cases within 12 hours had chills and fever, but 24 hours later the temperature came down to normal or to 100°. In 17 per cent of the 500 cases the temperature after the curettage remained normal.

As far as morbidity is concerned, of these 500 cases I do not know the number of pelvic abscesses or tubal infections. There was no packing in the uterus after curettage. The hot iodine douche, usually running from 110° to 120°, helped to contract the uterus so that there was no hæmorrhage. The curette was used only when the placental tissue could not be removed with the finger.

There is some complaint on the part of practitioners that tent dilatation causes infection. We did have elevation of temperature within the first 24 hours afterwards but we had no serious infections. We have used tents in preference to the Hegar dilators because of the danger of injuring the cervix.

Dr. Emil Ries (closing): There have not been very many points brought out in the discussion that require answering. There is a remarkable unanimity on one side and some straddling of the fence on the other.

I want to emphasize what Dr. Holmes said about the medico-legal aspect of this question. In the last twenty-one years I have been teaching postgraduate students. We have men at the Post-Graduate School who come from all parts of the country and who go out into active practice and see many of these cases, and they ask me now and then about the medico-legal aspect of these cases, and they say to me every now and then: "This may be all right with you, doctor, in your hospital, but what would you do in our practice." They say: "If I do not clean out the uterus, the people will send for somebody else, and he will clean out the uterus." That is no argument at all. If a woman wants to have a criminal abortion performed by me and I refuse, she will go to somebody else, and I will lose the case. That is no argument that I should produce criminal abortion. I do not have to get the practice of the whole town, and what I do in my cases is to give them the best treatment I know. The medico-legal aspect is a very serious one. Those of us who first introduced the expectant treatment in our practice realized that we knowingly and consciously exposed ourselves to the danger of very serious trouble of a medico-legal kind. In court the practice of the day and time and place where you practice are a standard for what you should do, and the man who introduces new methods exposes himself to the risk of having every old textbook used against him and every old practitioner standing up against him in court, telling him that he has done the wrong thing.

I might answer a few of the other points that were brought out. Dr. Holmes spoke of bacteriological examination and of the question of being guided by the finding of streptococci. The streptococcus question is a terrible one. There are some men who say that if you find streptococci you should institute active treatment, while others teach that when streptococci are found one should resort to

the expectant plan of treatment. If one goes carefully over the literature of the bacteriology of septic abortion, he will find that it is absolutely impossible to be guided by it. There is only one use I find, and that is this, if we have one of those rare cases of diphtheritic infection of the perineum, or vagina, it is revealed immediately by the bacteriologic examination and we are guided as to the proper treatment. Aside from that, I see no way of being guided by the bacteriologic examination.

The doctor mentioned also the question of odor with discharge and treatment by douching. One may douche if he wishes to. But if these cases that have an odor with discharge are not douched and are kept clean they get well.

Dr. De Lee wanted to know what I would do if the packing was removed, whether I would dilate in every case. I dilate only those cases in which the packing has not produced sufficient dilatation. If the packing has not been carried to such an extent that the cervix admits one finger, I use a few Hegar dilators.

The doctor spoke of douching for the removal of small particles. If I can leave a handful of placenta with impunity I do not care very much whether I leave small particles or not. If the uterus is cleaned out, if the placenta is cleaned out, the particles will come away by and by.

With reference to the remarks of Dr. Barrett, in the cases he referred to the uterus was not emptied at all. It is not necessary for the uterus to be emptied for the temperature to become normal. The doctor wants to know why do we ask whether the placenta is complete after the placenta has come away. He knows why. I need not tell him, but I will tell you, because if the placenta is not complete we may expect the formation of placental polypi which lead to hæmorrhages. That is a question of hæmorrhage, not of sepsis.

Dr. Barrett brought up the question of therapeutic abortion and said these patients always do well. He answers the question himself: it is because we take such cases at the time of choice when everything is all right. They are not cases of septic abortion; we have to deal with a clean field. I do not quite understand what this has to do with the question of septic abortion. I am impressed with the fact that we can cure almost any case of tumor, but there is nothing in which we are so powerless as in the treatment of sepsis.

I want to say a word or two in answer to Dr. Lackner. There can be no greater difference between the two treatments carried out in the same hospital than exists between the treatment which I carry out and the treatment which has been practiced by my predecessors and as it is practiced by the gentlemen alternating on the service with me. I have read carefully Dr. Lackner's paper and he states the mortality correctly when he says it is eight-tenths of one per cent, one of the cases out of the 500 having been treated expectantly. His paper does not give the morbidity. There is nothing said in the paper about pus tubes, pelvic abscesses, and so on.

Finally, we as gynecologists, who have introduced the active treatment of septic infection, have to fight to get it out of the heads of the general practitioners. The general practitioners did not introduce this active method of treatment in septic abortion, but gynecologists did, and I think we will do well if in time we succeed in convincing at least the majority of the profession that hands off the puerperal uterus, hands off septic abortion except for hæmorrhage, is still the best method.

THE CHICAGO SURGICAL SOCIETY

REGULAR MEETING OF THE CHICAGO SURGICAL SOCIETY HELD MARCH 2, 1917, WITH THE PRESIDENT DR. WM. M. HARSHA, IN THE CHAIR

PRESENTATION OF A SPECIMEN OF DUODENOJEJUNAL HERNIA

DR. KENNETH HALLOCK: This is a specimen of a complete hernia of the small intestine into the duodenojejunal fossa. As to the clinical history of this case no information can be given except that the hernia was not the cause of death and was not discovered until autopsy.

The pancreas and duodenum lie to the right of the orifice of the sac in their normal location. The inferior mesenteric vein is seen passing upward to the left of the orifice and then curving to the right above the orifice. It lies within the plica venosa.

The orifice of the sac lies to the left of the ascending portion of the duodenum and below the plica venosa and inferior mesenteric vein. The orifice admits the tips of three fingers easily.

Only one loop of bowel, the efferent loop, passes through the orifice. The efferent loop, which frequently happens in such hernias, has become fused with the structures of the posterior abdominal wall and enters the sac behind. The hernia is not reducible, due to adhesions within the sac. However, no signs of strangulation are present.

The sac itself is directed upward and backward and lies just below the diaphragm between the peritoneum and posterior abdominal wall. The

peritoneum is thin and glistening and through it can be seen the loops of the small intestine.

As to the origin of such hernias, it depends largely upon the position of the inferior mesenteric vein. This may lie in the midline of the fœtus, or laterally. In this case, the traction of the pancreas and duodenum to the right and of the mesentery to the left causes the vein to lift upward, especially if it be taut, and a serous reduplication, the plica venosa, is formed. This is the starting point of the orifice of the sac.

The conditions necessary for the formation of such hernias are: the existence of the fossa, the presence of the inferior mesenteric vein and fold and finally, the motility of the small bowel.

The size of the hernia is determined by the laxity of the retroperitoneal tissues and the distensibility of the peritoneum. These conditions may be met with even in intra-uterine life; however, the youngest person in whom such a hernia has been reported was fourteen days old (Broesike). About one hundred hernias of this kind have been reported.

Moynihan in his monograph mentions nine fossæ into which retroperitoneal hernias may occur and says that the paraduodenal fossa is the most frequent seat of hernia. He says that herniation into the duodenojejunal fossa is unlikely since to expose the orifice, the mesentery of the transverse colon must be drawn tightly upward and the jejunum to the right. The paraduodenal fossa as he described it coincides almost exactly with the duodenojejunal fossa of the authorities on anatomy.

THE METHOD OF NEW JOINT FORMATION IN ARTHROPLASTY

DRS. PHEMISTER AND MILLER presented a résumé of their extensive experimental study on new joint formation (see p. 406).

ARTIFICIAL IMPACTION OF SUPRACONDYLOID FRACTURES OF THE HUMERUS IN CHILDREN

DR. PAUL F. MORF: Supracondyloid fractures of the humerus are those found at that part of the lower end of the humerus which is subjacent to the origin of the supinator longus muscle. Clinically, of course, it is not always possible to differentiate between a separation of the lower epiphysis of the humerus and a fracture just above the articular surfaces of humerus and a supracondylar fracture unless recourse is had to the X-ray. The ordinary course is to reduce the fracture and put the arm up in the Jones position. This method keeps the fragments in relatively good position but does not always accomplish all that is to be desired in the way of results. This was impressed upon me by a case I saw some time ago which led me to search for another method.

A little child one and a half years old, at the County Hospital, had a supracondyloid fracture. It was reduced by a member of the house staff but afterward it was found that dislocation of the fragments still persisted. I proceeded to reduce the fragments and put the bone up in what I thought was a very good position, but an X-ray disclosed that it was just as bad as ever. I referred the case to Dr. Speed and after he operated on it I observed that the result was no better than that I had obtained.

I, therefore, concluded that the fragments had slipped out of position, and this led me to try to find some better method of keeping the fragment in position. We have all used the nail, and the plates, and put in bone graft, making two compound fractures to heal a simple one. We hesitate to perform such operations in the neighborhood of joints, and especially in children where an injury to the epiphyseal line may interfere with the growth of the bone. I happened to run across some work of Cotton of Boston on impacting intracapsular fracture of the neck of the femur, and it appeared to me that it might be feasible, after reducing the fragments in supracondylar fractures, to do an impaction. There is no reason why this cannot be done at the lower end of the humerus. If the fragments are reduced and the forearm flexed and a blow is struck on the olecranon, the force will be transmitted to the lower fragment. As most of these fragments show more or less dentate outlines there will be little tendency to displacement after impaction. There is no reason to fear that this can do any damage. In order to demonstrate this I tried the procedure on my own elbow before I tried it on any of the children and it was not accompanied by any pain or discomfort. We used an ordinary wooden mallet, or a wooden potato masher, covered with such felt as the orthopedic surgeons use in making plaster casts.

I believe that any method for the treatment of fractures can be judged more or less by the ease by which it can be applied. We all realize that one of the difficulties in the Lane plate is the danger of sepsis. We have all succeeded in putting in these plates and had them hold in place and occasionally some one else has had to take them out sooner or later. The artificial impaction is a method that can be done by anyone, even the general practitioner. If he impacts these fractures he will do no harm and the results will probably be good. The objection has been made that we do not know whether we have the fragments in good position or not. We have made an effort to control this difficulty by using X-rays. Whether we impact or not we do not know whether the fragments are in good position after reduction. If we find that the ends are not in perfect apposition it is very easy to break up the impaction because it is not extensive. We were able to demonstrate to the assistants and the class and clinic that after impaction movements could be carried out almost as well as before fracture had taken place and that there was no tendency for the deformity to recur. Several showed the impaction very plainly on X-ray plates.

There is one thing that I have observed in doing this work. In reducing the dislocated fragments on the lower part of the arm, one is inclined to think that reduction is complete when a line overlying the triceps muscle is a straight line. As a matter of fact, it is not a straight line but often is a very strongly curved line. If the arm is thin the line may be nearly straight, but as most of these fractures occur in children who have plump arms, and they come with a great deal of swelling, this line is strongly curved with the convexity backward, and if we reduce simply to a straight line the reduction is not complete.

DISCUSSION

DR. FRED B. LUND: I have been a good deal interested in Dr. Cotton's work in fractures. He certainly secures very good results. However, I have attributed the results more to the fact that he brings the fragments into good apposition by abduction of the thigh, than to the fact that he hits the bone with a mallet. In Baltimore last fall Dr. McLennan showed his results in reduction of the femur. Whitman's abduction treatment and the results were equally good. I believe that Cotton's results are due to the fact that he forces the surfaces tightly together. I think Dr. Morf has shown us some beautifully reduced fractures and has made a demonstration of what I have firmly believed for thirty years: that these fractures should be reduced by acute flexion, for in that way they are forced into anatomical position. If we are sure the fragments are in good position to hit it with a mallet once or twice does no harm, but I think that is not the important part of it.

DR. COLEMAN G. BUFORD: I have the privilege of seeing a good many fractures in infants and small children and think that this particular group of fractures come to the Children's Memorial Hospital in greater numbers than any other two groups. I have been impressed with the frequency of pronounced external deformity and the actual bony deformity shown on the X-ray plates. The arms are probably laid upon the plate by many X-ray operators without due regard to the most correct position obtainable at that time, placing the elbow on the plates in whatever position they happen to best lie, thus often giving very bad looking positions.

Supracondylar fractures are among the easiest to reduce. The soft parts are not very thick in that locality and only a little extension and some manipulation at the elbow brings many of them back into position very easily. If correct position be not obtained it is because of interposition of the soft parts or some unusual obliquity or displacement of the fragments. It has been my experience that when reduction is complete and the arm is put up snugly, and in the correct position, the fragments do not slip out of place. Concerning the position of full flexion as a means of treating these patients I beg to differ with our distinguished visitor.

The dogmatic teaching of complete flexion as a routine in the treatment of fractures near the elbow-joints is a mistake. I think that is just as big a mistake as to teach the use of vertical extension as a routine in the treatment of fractured femurs of infants. You can take the X-ray plates of both classes of these fractures and pretty accurately estimate what position you must put them in to assist best in keeping the fragments in position.

Correct position gives the least callus and, therefore, interferes the least with future joint movement. It is the displaced fragment which is accompanied by the excessive callus. Most of these supracondylar fractures in children show backward displacement of the lower fragment. Reduce them if you will and then put them up in full forced flexion. What happens: the flexed forearm carries backward the lower fragment. There is a correct angle for each of these cases; surgeons must individualize.

Again and again I have treated these fractures in full extension and have only one regret. When that patient was last seen his motion was returning.

DR. MORF (closing): As to whether these fractures are impacted or not, I asked myself that question and think the best answer to that is that after reducing and before impacting them, I tried to carry out flexion and extension and then they slipped out of place pretty easily, but after impaction they did not do so. A good many of the patients were able to move their arms pretty thoroughly at the end of two or two and a half weeks and I believe that the impaction did some good. As to putting them up in acute flexion, I fully agree with Dr. Buford that it is not successful in all cases. Some of these I showed were not in acute flexion but most of them were.

BOOK REVIEWS

A CRITIQUE OF NEW BOOKS IN SURGERY

IT is conceivably possible to cavil at the policy of reviewing a book not devoted solely to the combined art and science of surgery, in a journal that frankly devotes itself to these two subjects. It is not conceivably possible, however, to doubt the expediency of doing this thing, in days drab and gray, when even a surgical journal has warrant to blaze the trail of furnishing new though unsurgical joys.

This autobiography by Gerster[1] contains every essential to the process of losing one's self for a time, getting out of the war, hearkening to nature, art, music, and reveling in that reactive play of mind which constitutes probably the greatest of all immaterial joys. And if all this doesn't prompt purchase, then it is easy, in conscience, to add the explicit injunction, so common in the deadly formal and perfunctory book review, that "the book should be read by every doctor."

Of course, as is the case in all such volumes, the charm lies in the essence rather than in the form—Origins, Childhood, School Days, University Life, Army Medical Service, Life and Practice in America, Reading, Sports, Travel and Hobbies:—surely these are conventional enough to group the book, label and classify it, and therefore fix it straightforth outside the desire of the casual reader. But then, an autobiography isn't really an autobiography unless it is true to form. Even Gorky's recent soul-shredding recital was more or less true to necessitous chronology.

But one forgets form and reads Gerster, much as the old lover and connoisseur of wine sips his glass, stopping every now and then to sniff the aroma more deeply. The opening chapter on Origins is headed by the quotation from Juvenal, "What do pedigrees amount to?", thus lending the tang of curiosity, without which genealogy is deadly. One learns as one reads, that the Gerster family tree *did* amount to something, and one learns also from such delicate touches as the comparison of the grandmother's death to the passing away of the Venetian Cornaro, and from the incomparable pen picture of the father, how a chapter on origins may be made to hold interest.

One could select with ease, and at random, shining examples of phraseology that make the book unique as a type of smooth, strong, vivid English prose; indeed to select enough of them to be prohibitive on the basis of space.

Those who are interested in pen-picture vignettes of the development of asepsis, or personalities like Skoda, Rokitansky, Dumreicher, Bruecke, and Hyrtl, of the fundamental excellencies and weaknesses in American primary and secondary education, colleges, medical schools, and hospitals as schools, of the joy of out-of-doors, of etching as an avocation, of the wreathes and crosses of practice, of national spirit and national consciousness, and of countless other things, those of you read this autobiography.

M. G. S.

IN searching the present day literature, one is often disappointed in not finding sufficient data on certain detail which is essential to a perfect understanding of a subject. The important facts are elaborated upon but minor topics are passed over with little or no reference. This applies to a considerable extent in most present day treatises on operative technique. It is most refreshing, at least to the careful reader and technician, to find in Doyen's work,[2] an exception to this rule. In glancing over the pages hurriedly, one is not well impressed, in fact rather the opposite, but a careful survey reveals a surprising amount of minor technique, so frequently omitted.

The work alluded to is Vol. I of a system of three volumes on surgical therapeutics and operative technique. This volume is divided into two parts. Part one considers general surgical technique, and part two, operations on the head. In part one, the author describes his surgical home and methods in detail, truly with some degree of egotism, but when one considers the results and work accomplished by Doyen—his place in the surgical world, especially in France, it is conceded, and one is only too grateful to have it so. It is one man's experience and technique, obtained during many years of study, and molded by many failures and successes. It is his advice and consultation.

The subject of hæmostasis is treated in the most elaborate fashion, giving its history, and a thorough scientific discussion, comprising some 90 pages. Considerable attention is given to the various types of instruments which the author has found necessary to carry on his work. Operations are considered from the standpoint of treatment before, during, and after the operative procedure. In this part he also describes the technique of the vascular suture and transplan-

[1] RECOLLECTIONS BY A NEW YORK SURGEON. By Arpad G. Gerster, M.D. New York: Paul B. Hober, 1917.

[2] SURGICAL THERAPEUTICS AND OPERATIVE TECHNIQUE. Vol. I. By E. Doyen, M.D. English Edition. Prepared by the author in collaboration with H. Spencer-Browne, M.D. (Cantab.). New York: William Wood & Co., 1917.

tation, blood transfusion, surgery of the nerves, the latter most carefully, treatment of fistula, and the treatment of cancer by electrocoagulation. The treatment of carcinoma includes reference to the micrococcus neoformans, the susceptibility of cancer cells to heat as a basis for his combined method of treatment, viz., excision and electrocoagulation, and the methods for attacking cancer in the various parts of the body. His apparatus is described in detail, with photographs. The chapters on plastic surgery are most interestingly illustrated.

Part two details the operations on the head. There is some repetition here from part one, but it is more apparent than real. The operations on the scalp, skull, brain, ears, visual apparatus, nose and sinuses are included, all clearly and profusely illustrated, especially those on the skull and eye. Many interesting details in technique are given, and the treatment of unusual conditions is described.

This work is so unique that it deserves a place in the library of every surgeon. The author impresses one with the many necessary details of a perfect technique, and unless a perfect technique is developed, there is much lacking in the surgeon. J. A. W.

AS a worthy companion to the previously mentioned work, appears Vol. I of a treatise on regional surgery edited by Binnie.[1] One is impressed by the gradual narrowing of the scope of the new treatises. This is undoubtedly brought about by the fact that many new fields have been opened in every branch of a surgical topic. If each of these is given the proper amount of consideration, and the whole topic is discussed, the system becomes so voluminous, that it loses its "punch" in an endless amount of detail.

This treatise of which Volume I is before us, will consist of three volumes. Volume I is devoted to the head — branchial system, thorax, and the breast; Volume II to the abdomen, genito-urinary system, and the spine; and Volume III to the upper and lower extremities.

The subject matter of Volume I is divided into sections, each of which is prepared by a man of recognized ability. In the preface, the author states that due to the difficulty in securing a suitable authority to write the chapter on diseases of the brain, this has been entirely omitted, rather than to have it a piece of "hack work."

All the topics are well presented and there are many original illustrations. Several sections deserve especial mention. The anatomy of the scalp is discussed very briefly but to the point. The treatment of angioma of the scalp is elaborate. The mechanism of skull fracture and cerebral compression is presented in an interesting fashion. If there is one outstanding chapter in the volume, it is that devoted to the branchial system. The development of this system and its association with anomalies and subsequent disease is treated most scholarly.

The sections given to the tongue, especially carcinoma of the tongue, the accessory nasal sinuses, Hodgkin's disease, the thyroid, parathyroids and thymus glands are complete. The surgery of the breast is well written with the exception of acute inflammation and abscess, which are scarcely mentioned. It is quite a disappointment after reading the masterly treatise on carcinoma and cysts to have acute infections placed in a position of comparative non-importance. Cysts of the jaw are also very briefly mentioned — again out of proportion to the subject as presented elsewhere.

The treatment of various conditions, as a rule, is outlined rather than given in any detail. This in itself is no detriment to the work, as the detail must be left to treatises on operative technique. J. A. W.

THE literature of the Mayo Clinic has again appeared in book form, the present issue,[2] containing the articles appearing during 1916. Little need be said regarding the character of these papers. As usual they represent the progress of the surgical and medical profession.

This volume is divided into six sections, viz., papers on the alimentary canal; ductless glands; blood; head, trunk and extremities; technique and general. It represents the literary production of 42 men during the year. Many of the less frequent conditions are considered in these papers; notably among which are blastomycosis of the tongue, radium treatment of lymphangioma of the tongue, adenoma of the palate, cysts of the larynx, toxic gastric hæmorrhage, tuberculosis and syphilis of the stomach, rupture of the common bile-duct, diverticula of the urinary bladder, and the active constituents of the thyroid.

There are few men in the profession who do not appreciate the individual papers presented by this clinic. The fact that this volume contains practically all the papers for 1916, neatly bound, makes it doubly attractive to the busy surgeon or to the man who does not have access to a library or to various journals, or cannot visit the medical centers frequently.

THERE is a great tendency in medical literature to refer to a certain pathological condition by giving it the name of the man who first called the attention of the profession to it. This is most confusing and leads to an endless amount of unnecessary repetition and description. It is interesting to read Pilcher's little volume,[3] and, if I am not mistaken, not see the word "Colles." Not that Colles should have less honor, but that our present literature should be more accurate and descriptive from a pathological standpoint, and less confusing.

[1] A Treatise on Regional Surgery. By Various Authors. Vol. I, Edited by John Binnie, A.M., C.M., F.A.C.S. Philadelphia: P. Blakiston's Son & Co., 1917.

[2] Collected Papers of the Mayo Clinic, Rochester, Minnesota. Edited by Mrs. M. H. Mellish. Vol. VIII, 1916. Philadelphia and London: W. B. Saunders & Co., 1917.

[3] Fractures of the Lower Extremity or Base of the Radius. By Lewis S. Pilcher, A.M., M.D., LL.D. Philadelphia and London: J. B. Lippincott Co., 1917.

This little volume, as its title would suggest, treats of the peculiar fracture of the lower end of the radius, giving the mechanism of the different types of fractures, and the anatomy of the wrist-joint, upon which so much depends. It is so simply written and clearly illustrated by sketches and X-ray reproductions, that it affords most interesting reading to everyone who may be called upon to see or treat fractures. It is of especial value to the teacher of surgery, because of the descriptive classification of such fractures. This classification is based wholly on anatomic considerations, the mechanism of production, and the resulting dissociation of anatomic parts. The treatment of such fractures is briefly given, but clearly illustrated, and leaves no doubt in the reader's mind as to how it should be carried out. J. A. W.

IN order to realize the advancement made in recent years in medicine and especially in the study of genito-urinary diseases, one need only glance over the pages of Keyes' new volume on urology.[1] This work is an up-to-date revision of the elder Keyes' text on genito-urinary diseases. Many of the chapters have been entirely rewritten and many new topics have been inserted. Notably among these are the subject of cystoscopy, renal function tests, pyelography and radiography. The chapter on infections of the kidney is new and up-to-the-minute and most interestingly written. Tuberculosis of the kidney is well presented but the author has to some extent failed in impressing the reader with the true importance of this most confusing and treacherous malady. Too little attention is given to the insidious character of the onset of symptoms and the multiplicity of conditions from a pathological standpoint which control and produce the symptoms.

There are several statements made in this volume which one cannot pass by without questioning. In the chapter on urine analysis the author states: "So long as there is much blood in the urine or acute prostatitis, a moderate albuminuria has no great significance, but in the absence of these, and even in the presence of slight microscopic hæmorrhage or of chronic prostatitis, the appearance in the urine of one-tenth of one per cent of albumin (by weight) means nephritis, and if there is pyuria, pyelonephritis." In discussing the mortality of prostatectomy, he states: "On the other hand, the average mortality of the specialist is 10 per cent, that of the general surgeon nearly 50 per cent." This latter statement brings to one's mind the difference between the man that does general surgery and the general surgeon, the author probably referring to the former.

The text is excellently worded and affords a striking example of high efficiency in choosing proper words and phrases to make the text exceedingly interesting reading. J. A. W.

[1] UROLOGY. Diseases of the Urinary Organs; Diseases of the Male Genital Organs; The Venereal Diseases. By Edward L. Keyes, Jr., M.D., Ph.D. New York and London: D. Appleton & Co., 1917.

DURING the past year or more we have heard much of radium, and its marvelous action on certain pathological processes. Most of the profession know that radium is used in the attempt to cure cancer, but its action and methods of application are a mystery to them. The report from the Memorial Hospital[2] affords a ready means of conveying to the physician the physics of radium, its methods of application, and the results to date in the treatment of cancer.

Chapter I, written by Failla, discusses the physical considerations relative to the application of radium. In very concise statements the author compares the X-rays with radium in its physical properties. Electrons and ions are defined and the rôles they play in radio activity are dwelt upon. The α, β, and γ-rays, their penetration and wave lengths are described, also secondary radiations are discussed from the standpoint of production and action. He describes the method of collecting radium emanation in tubes, the latter to be used in their treatments of cancer, thus eliminating the danger of losing the radium. In discussing absorption of radiation, the various metals and inorganic substances are taken up with the view of determining their absorptive power and their possible use in screening the rays during radium application in therapy. The various types of applicators are described, also the millicure which is the unit of radiation. Dosage is discussed from the standpoint of amount of emanation, and absorption either by air, tumor tissue, or screens, and the susceptibility of normal tissue and tumor cells.

Chapter II written by Janeway treats on the application of radium in cure of cancer. The author discusses the general methods and applicators and then gives his results, classifying the cancer anatomically. Many case histories are given, the dosage in millicures, screenings used, and length of application with results. At the close of the chapter a tabulation is given; a total of 424 cases have been treated. Included in these cases are 12 cases of sarcoma, 7 lymphosarcoma, 5 teratoma 5 epulides and several mixed tumors of the parotid. One hundred and sixty-two cases were unimproved, 59 cases were under treatment and 21 cases free from recurrence for one year or more. The majority of cases were more or less recently treated and the end-results cannot therefore be given.

Chapter III, written by Barringer, discusses radium treatment of bladder and prostatic carcinoma. The author gives the technique, usual dosage, and case reports.

Every physician has now at hand a ready reference on radium therapy, and every physician should make use of it, not that he can become proficient in radiumtherapy but to intelligently advise his patients who are suffering from carcinoma. J. A. W.

[2] RADIUM THERAPY IN CANCER. At the Memorial Hospital, New York. By Henry H. Janeway, M.D. With the Discussion of Treatment of Cancer of the Bladder and Prostate by Benjamin S. Barringer, M.D., and an Introduction upon the Physics of Radium by Gioacchino Failla, E.E., A.M. New York: Paul B. Hoeber, 1917.